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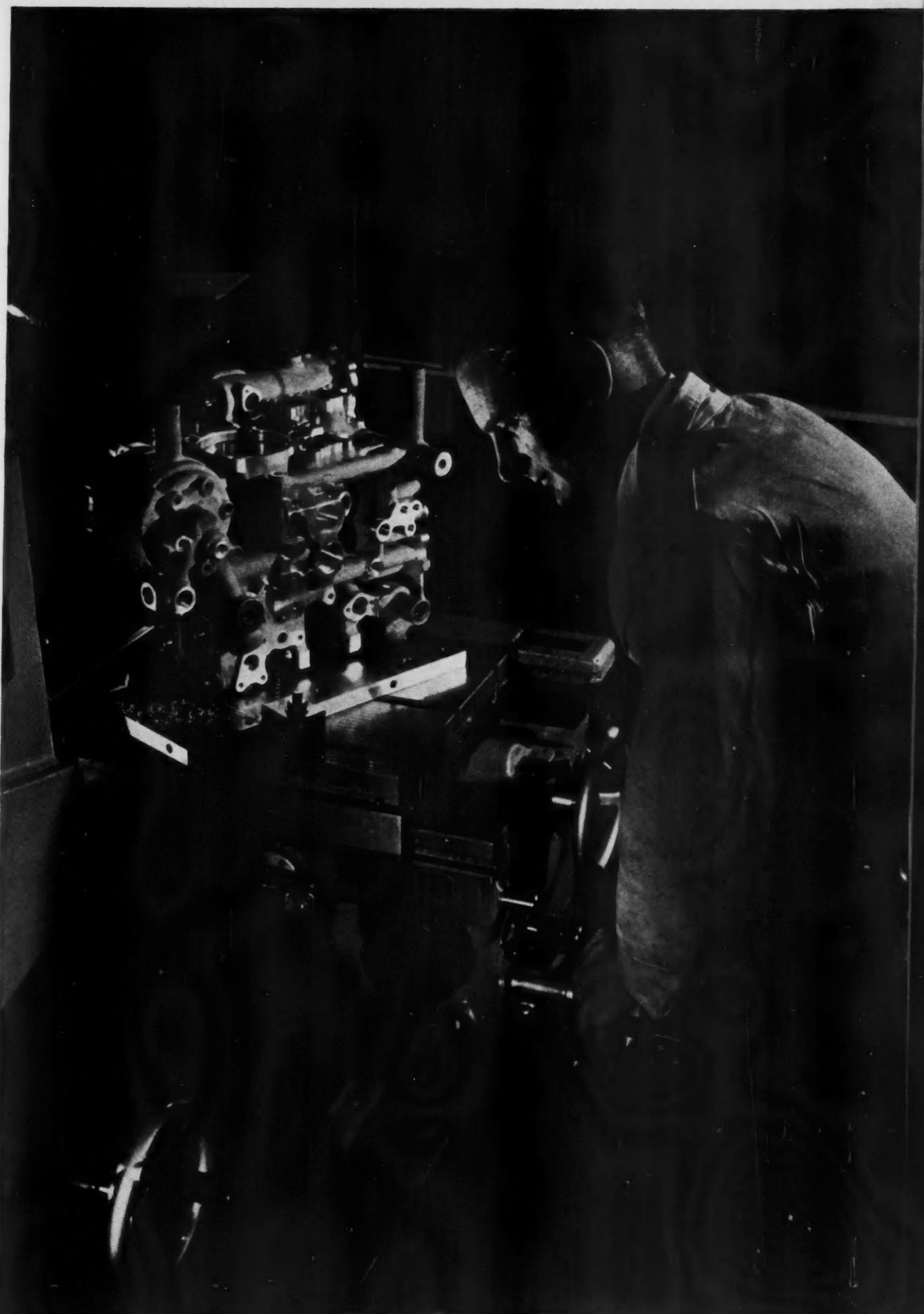

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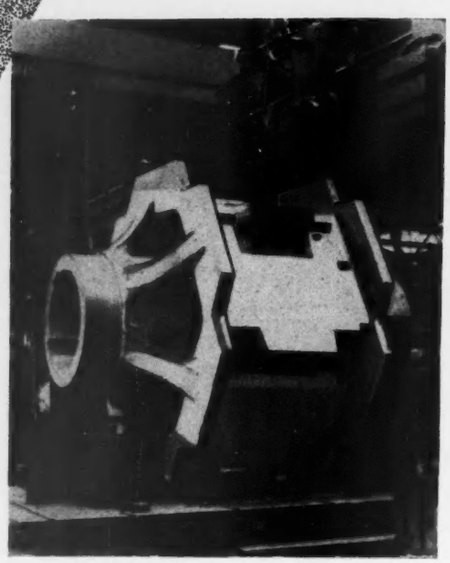
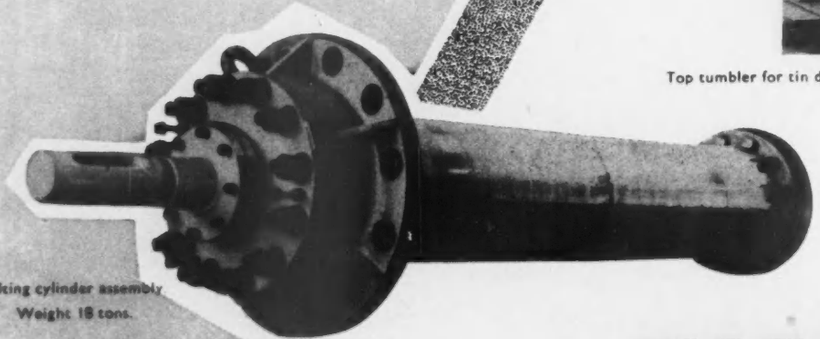


Top tumbler for tin dredging. Weight 17½ tons.



Tilting cylinder assembly Weight 18 tons.

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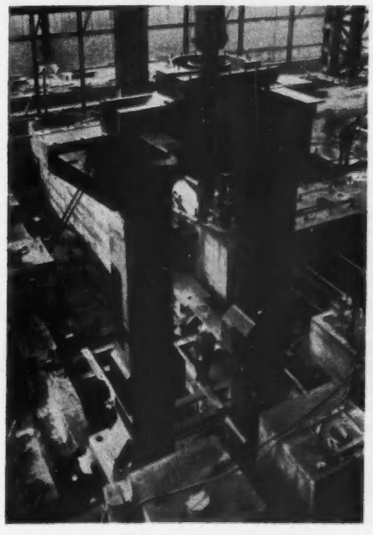

Of five new major plate rolling plants under the British Iron and Steel Industry's development programmes, Davy-United secured orders for three—Appleby-Frodingham Steel Company, South Durham Steel and Iron Company Limited and Consett Iron Company Limited.

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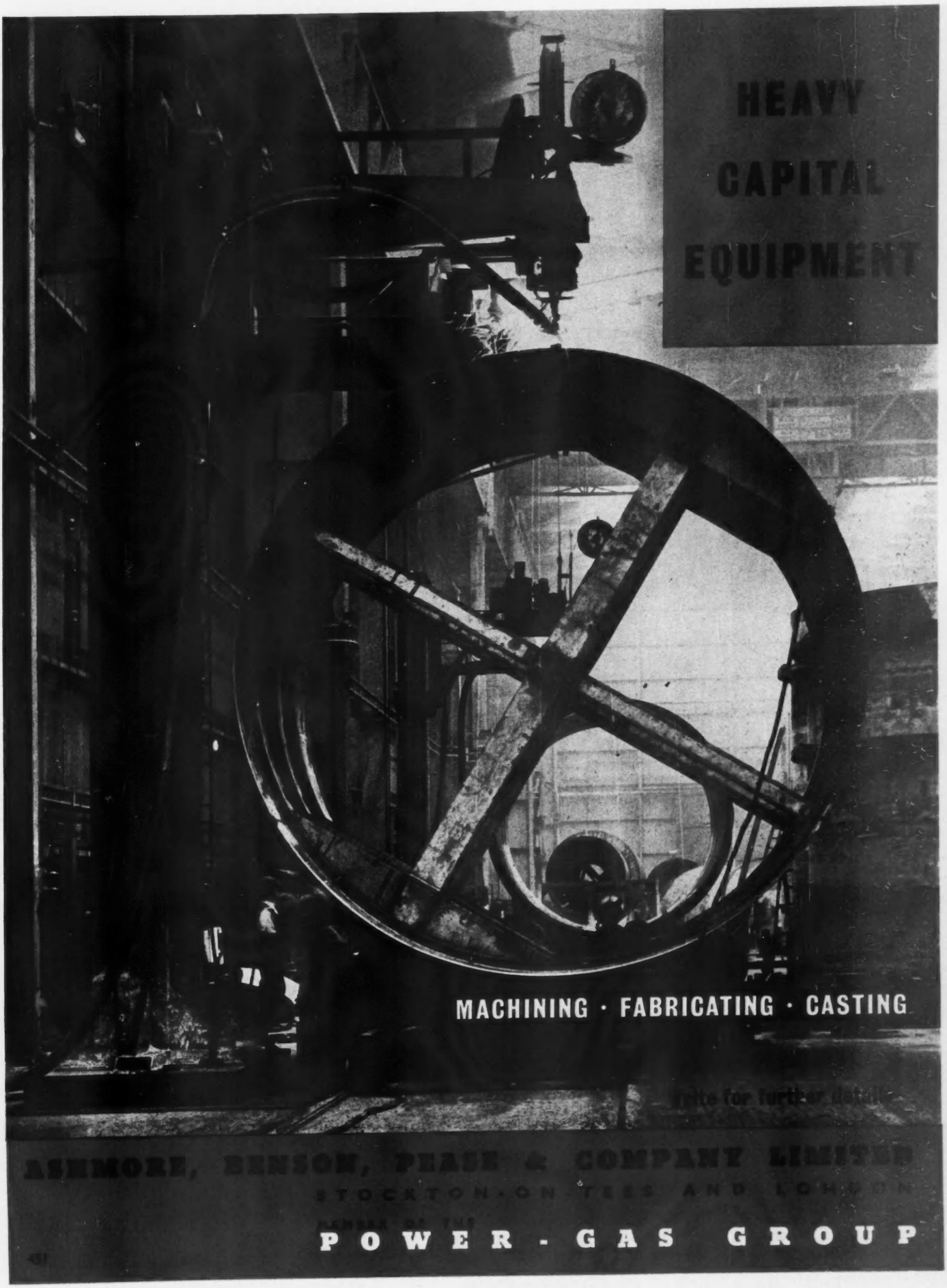
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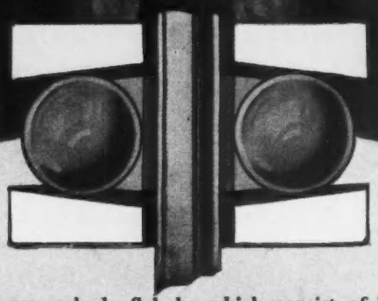

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Cover Picture

To make an aircraft gas-turbine fuel control system of minimum weight and compactness, all the components are mounted on a central casting which houses the filters, fuel pump and starting valves as well as the flow ducts between these components and the metering and flow control units. The photograph shows the central casting of such a system being finish machined. (*Nurnberg photograph for* ENGINEERING.)

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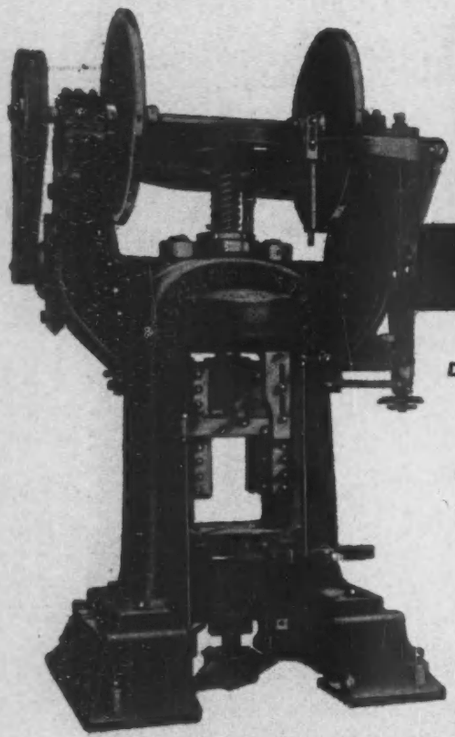

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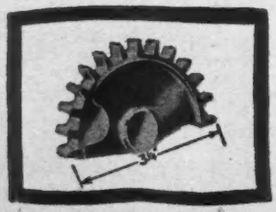

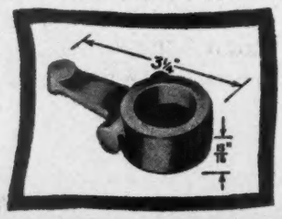

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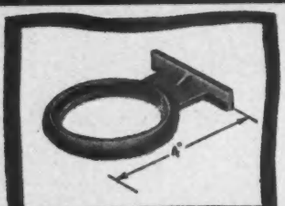

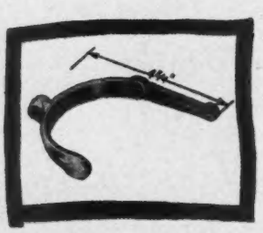

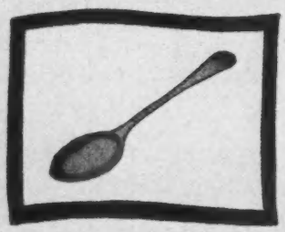

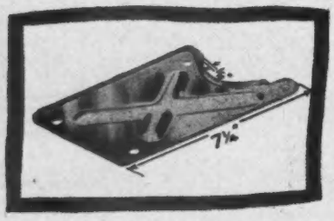

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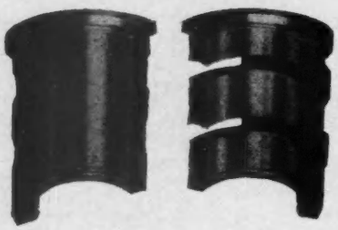

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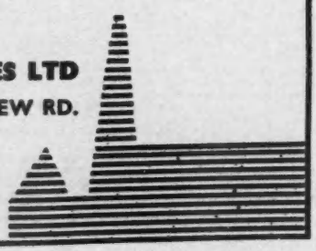

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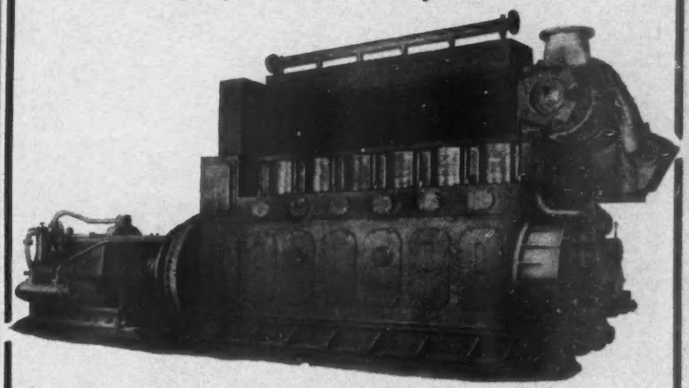

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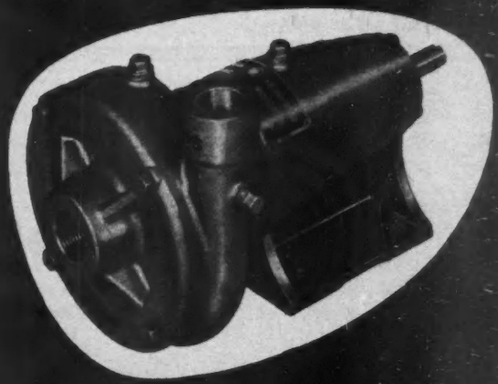

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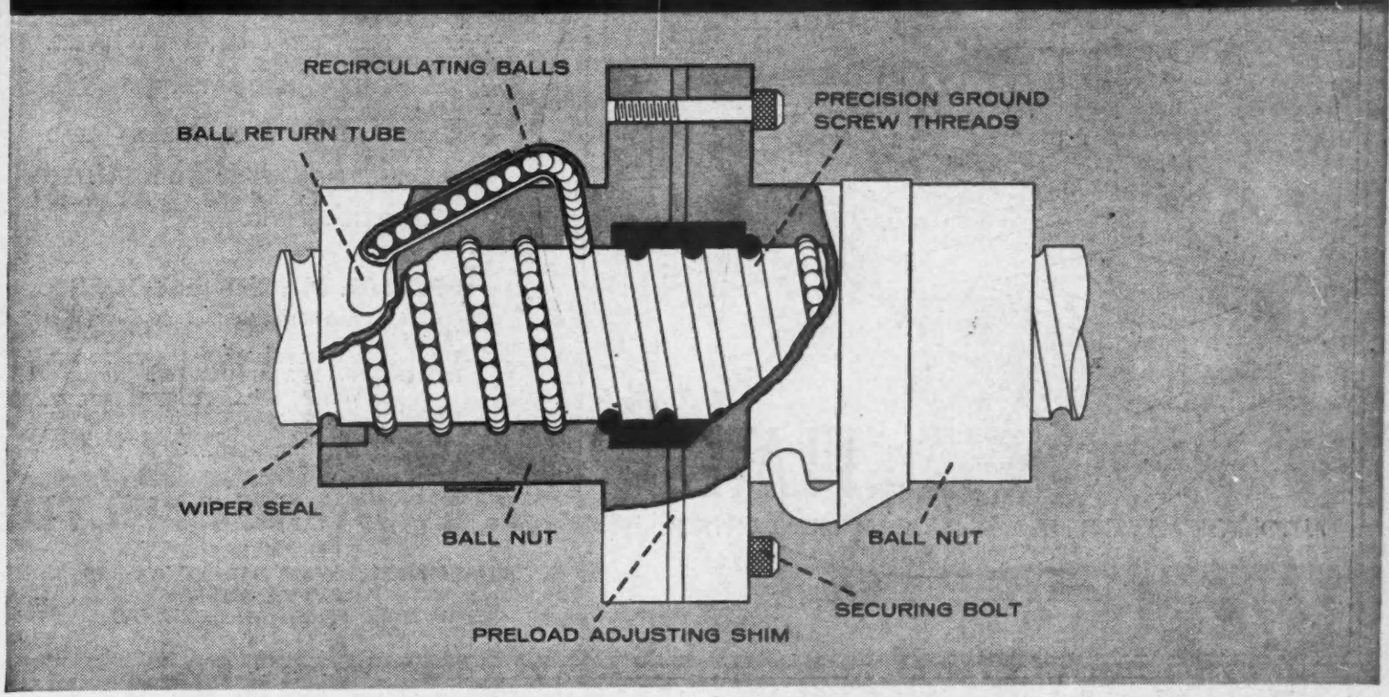

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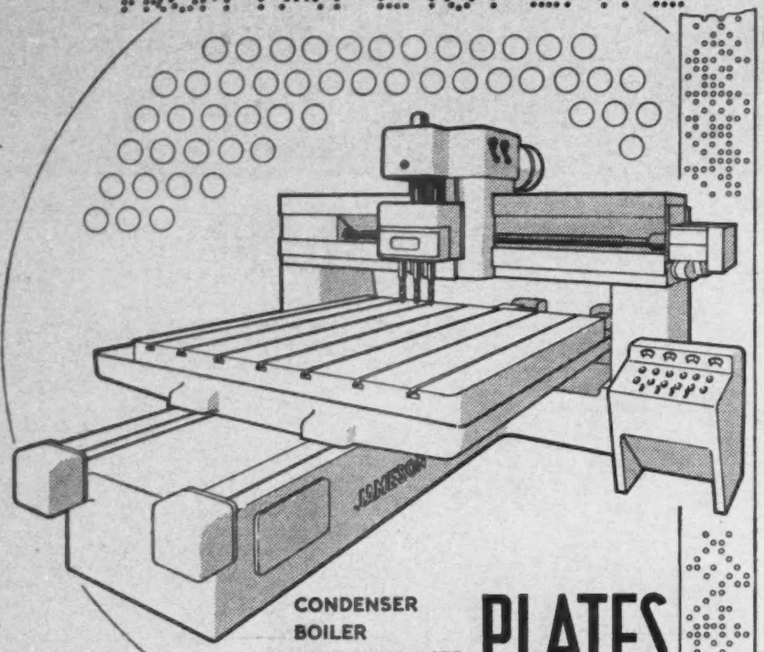

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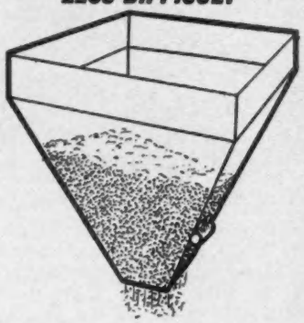

The installation of an external vibrator to a steel hopper.

trouble-free bunker discharge

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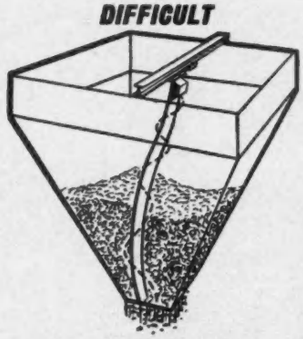
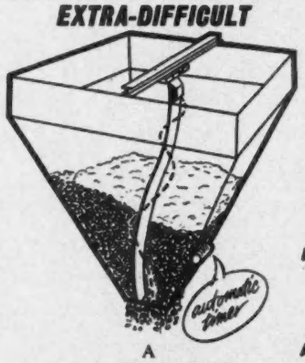


The vibrating reed for application where external vibration is impractical due to structural or other difficulties and if the bunker is made of concrete.

EXTRA-DIFFICULT



A combination of internal and external bunker vibration. Where the external vibrator is timed for 'on and off', the vibration frequency, on slowing down, goes through the natural resonance of the bunker, irrespective of load material contained.

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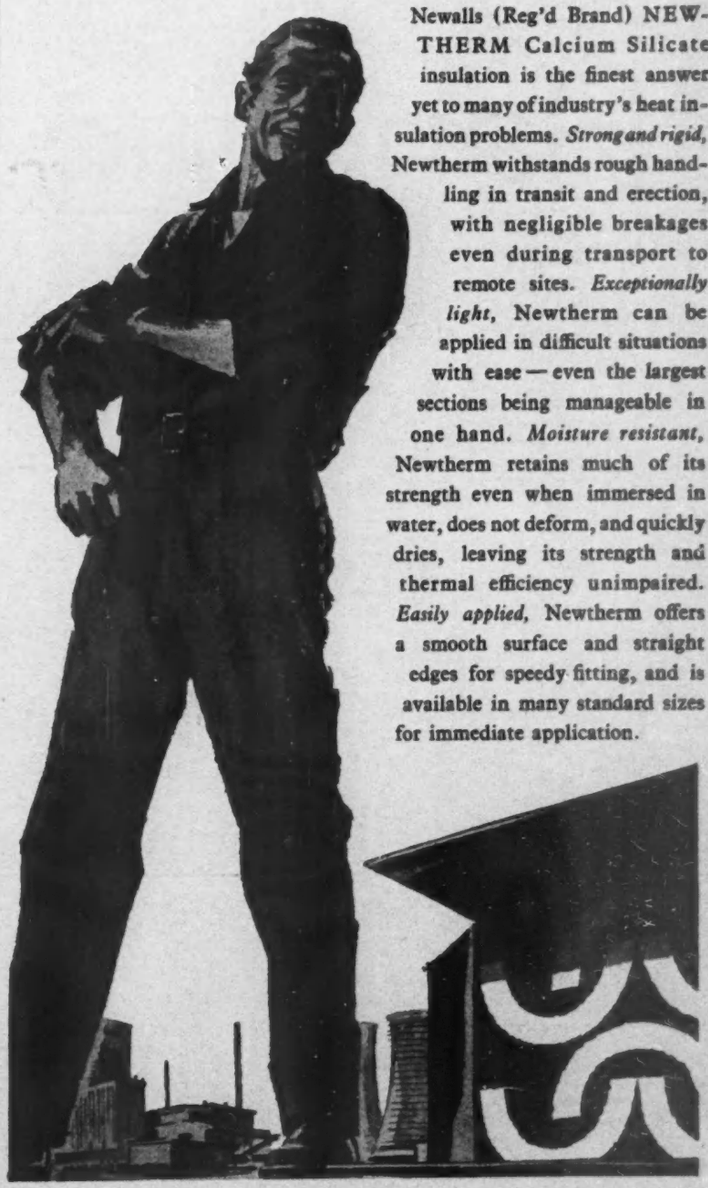

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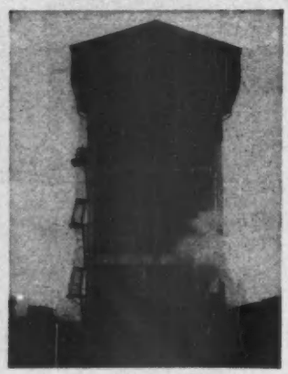

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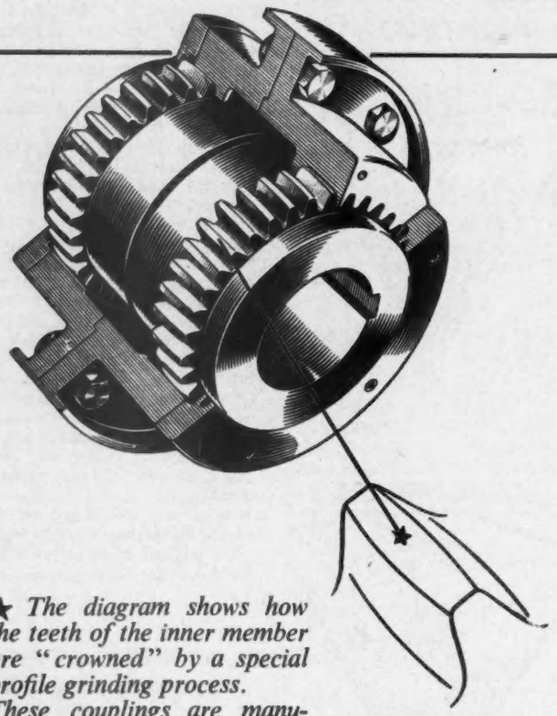
a gear type coupling



★ *The diagram shows how the teeth of the inner member are "crowned" by a special profile grinding process. These couplings are manufactured from high grade steel, in eleven standard sizes, and two types.*

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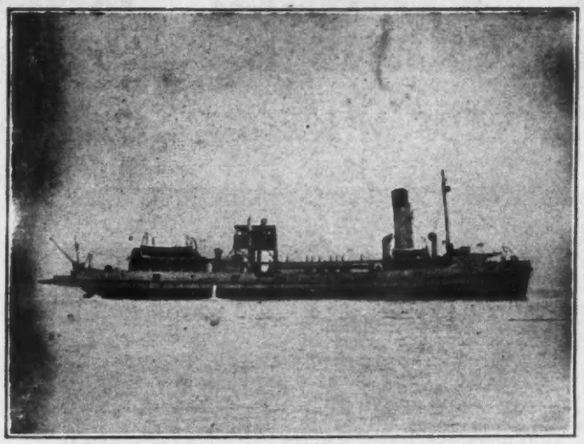

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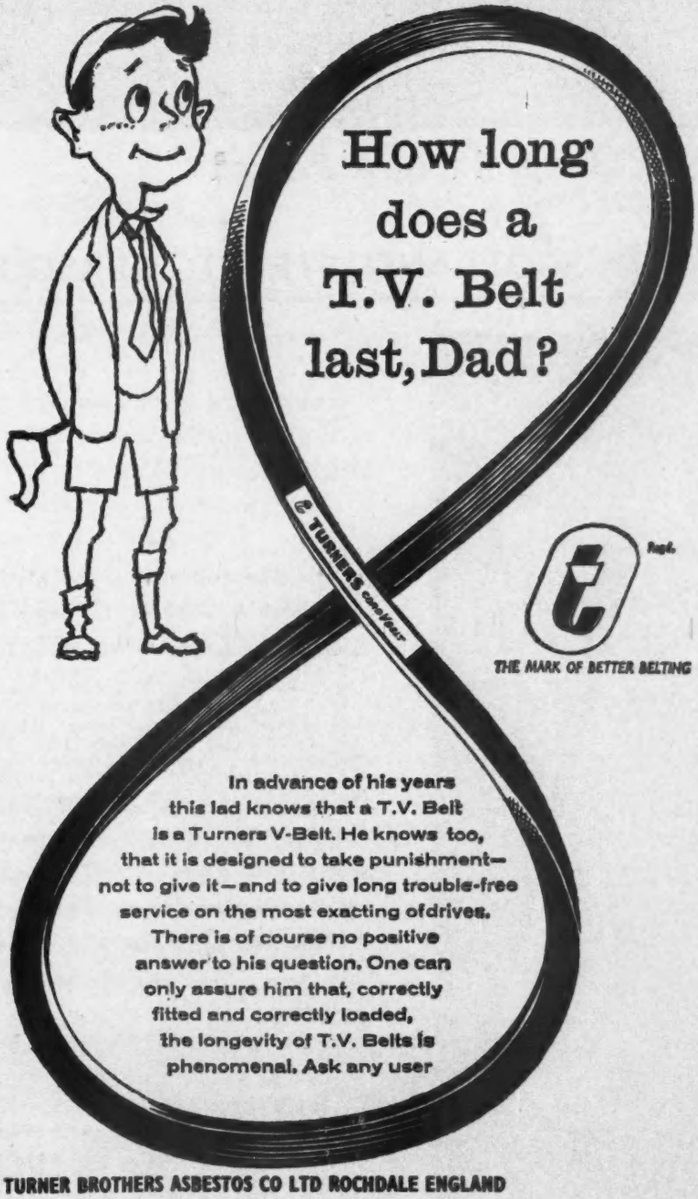
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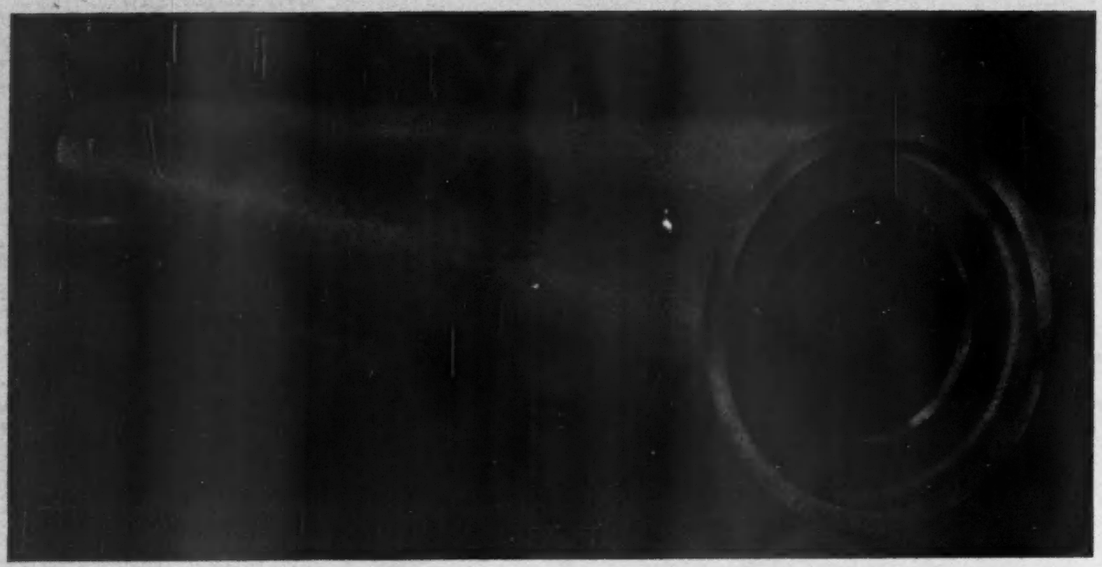

A WINDING DRUM 30FT. LONG × 2" THICK

Enquiries to

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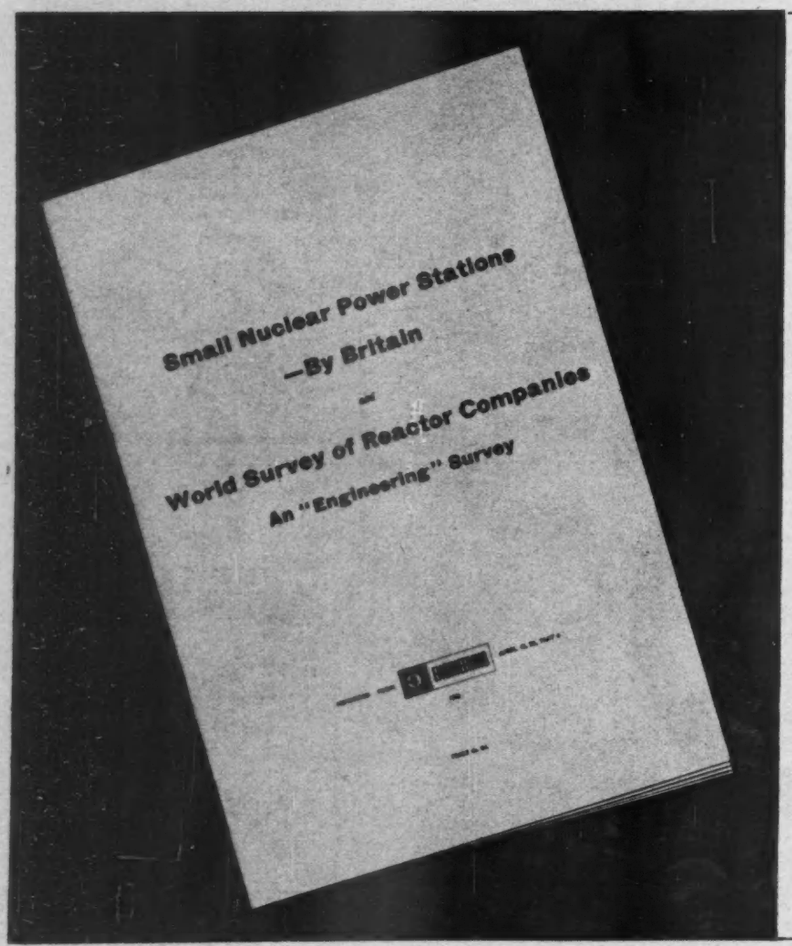

Britain's projects for small reactors (11-60 MW) are described by the heads and chief project engineers of nuclear departments of Babcock and Wilcox; de Havilland Engine Company; English Electric Company; GEC-Simon-Carves Atomic Energy Group; Hawker Siddeley Nuclear Power Company; Humphreys and Glasgow; Mitchell Engineering; Rolls-Royce and Vickers.

This reprint from 'Engineering' also contains a unique chart of World reactor companies and their associates, and of their activities in the nuclear field.

Reprinted from 'Engineering', April 15, 22 and May 6, 1960. Price 4s. post paid from 36 Bedford Street, London WC2.

ENGINEERING

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... of engineering problems off your mind

One example is the new, smooth-working, easily handled cargo crane, designed and manufactured by Stothert & Pitt, and tested in collaboration with the Saunders-Roe Foil Strain Gauge Field Service.
The use of Foil Strain Gauge techniques can lead to more efficient designs with consequent economies in production and cost over a wide range of industrial activity.
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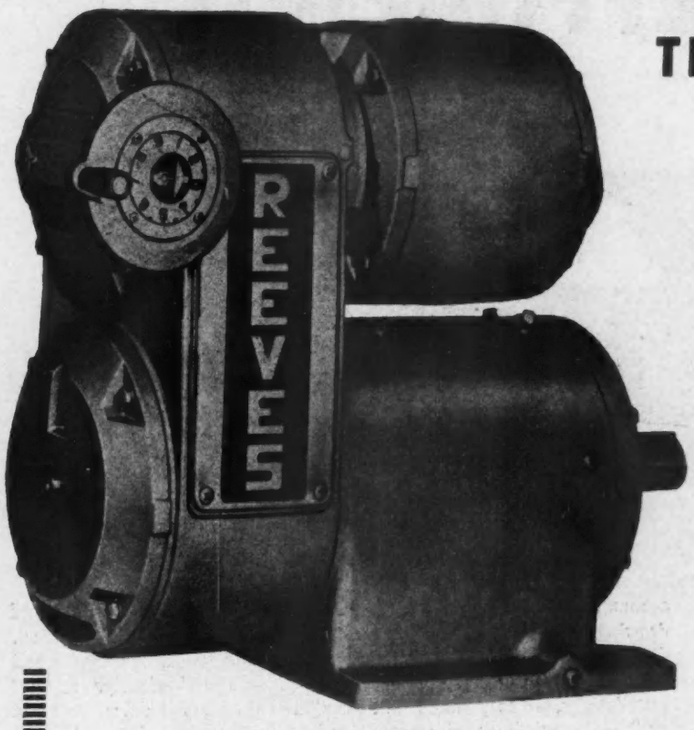

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The fresh, compact styling . . . the improved operating performance, . . . and the REEVES record of long trouble-free service on installations throughout industry have established the REEVES Motodrive as a preferred unit for variable speed requirements.

The REEVES Vari-Speed Motodrives are complete variable speed power packages designed to give ultimate performance and operating efficiency to applications in every industry. Right Angle Reducer units are also offered with the same rugged construction and simplicity of operation for year-round dependable service.

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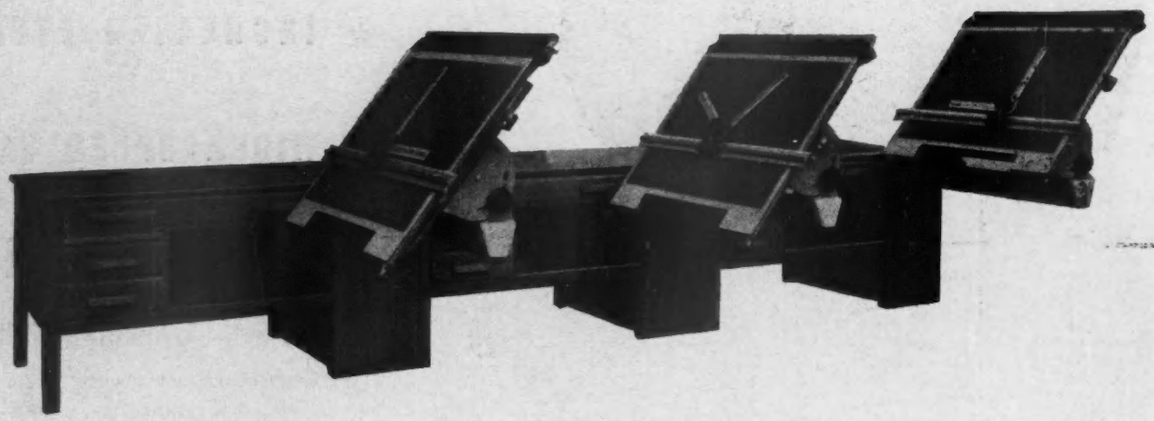

THIS is another Mason drafting efficiency development which has been designed to make completely full use of available space and, at the same time, to provide the draughtsman with every desirable and convenient reference, labour, time and space saving facility. The Unit provides absolutely rigid support for the drafting stand assembly and is ideally partnered with Arclight reference units. Whether used in large or small assemblies the equipment ensures drafting comfort and freedom of drafting movement with the minimum of physical effort. The Arclight Cantilever Drafting Unit enables the draughtsman to work without the slightest impediment to his legs and feet. The unit has been designed to accommodate a Mason Minor drafting stand with any of several types of drawing board assemblies, according to choice. Also, it has been designed with a view to its use in conjunction with Arclight wood reference tables. The equipment can be used in variously arranged installations, or as a single unit installation in a small office, or as an addition to existing equipment. The inestimable value of this cantilever idea is to be found in its characteristics of providing unrestricted drafting positions, flexibility of arrangement with reference units and filing equipment, attractive appearance and overall cleanliness—a new conception in drafting efficiency.

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DRAFTING DURAfilm

THIS is a wonderful material for all purposes and uses, ideal for either pen, pencil or type. Drafting Durafilm has been treated with an antistatic compound, to combat any build-up of static electricity, thus improving its resistance against dirt and facilitating its use in a copier. It is extremely fast in print use and when used in conjunction with a high contrast diazo paper, produces prints of uniform quality and maximum contrast. Drafting Durafilm has a fantastic strength; masters or drawings produced on Drafting Durafilm, with the ease of paper, are virtually indestructible.

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They spin them out down under

This is not a reference to Aussie spin-bowlers but to the David Brown underfloor spinning machine for castings in *Taurus bronze, bringing the enormous advantages of centrifugal casting to the solution of complex metallurgical problems.

David Brown were pioneers in 'spinning 'em out down under', but there is a lot more to it than the mere rotation of a mould! Over the years they have developed the right techniques for producing flawless bronze castings.

**Independent tests, confirmed by the National Physical Laboratory, proved that Taurus bronze was superior to every other bronze tested—and these tests included those from every leading manufacturer in this country and overseas.*

YOU CAN SAFELY SPECIFY DAVID BROWN TAURUS BRONZE CASTINGS

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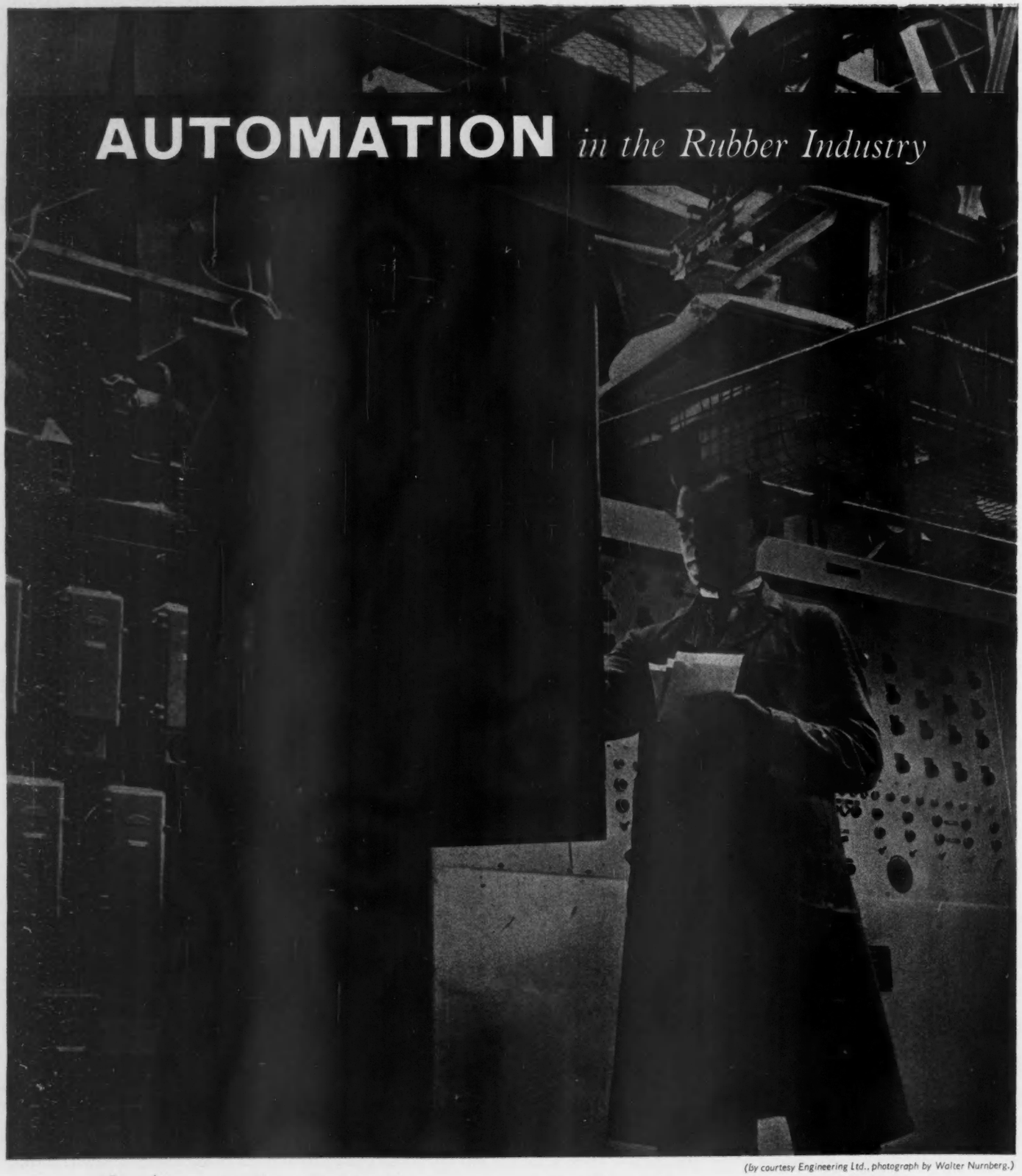
AUTOMATION *in the Rubber Industry*



(by courtesy Engineering Ltd., photograph by Walter Nurnberg.)

Setting up a formulation in an automatic plant for compounding rubber

Rigid specifications and the concise requirements demanded by modern industry, call in turn for great accuracy in the compounding of rubber mixes. Here the operator at the control panel of the first automatic rubber compounding plant in operation in the British Isles, is seen determining the necessary ingredients and quantities, so as to ensure this accuracy. Thereafter the various silos situated above automatically release the required amounts into hoppers which then move into the rubber mill.

Empire Rubber Company – Rubber Bonders Limited are designers and quantity manufacturers in rubber and synthetic rubbers. Principally they serve the motor, transport and engineering industries where their help is enlisted in the use of rubber as an integral part of engineering design. In these days of advanced techniques, Empire Rubber – Rubber Bonders solve many manufacturing problems.

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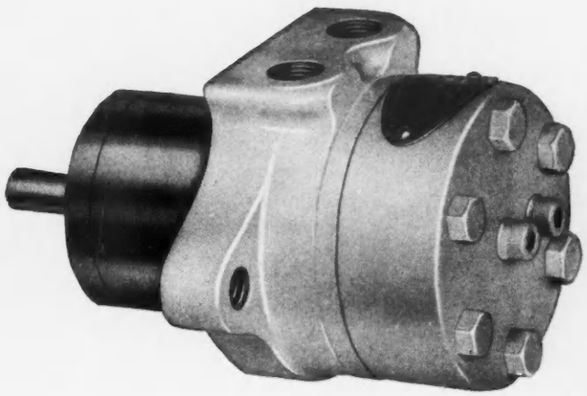
CONTROL OF MOTION



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At pressures up to 1,500 p.s.i. and running speeds as low as 20 r.p.m. the Savery Annular Piston Pump maintains a positive, smooth and consistent flow. It is capable of infinite regulation between zero and maximum volume, and is in a class by itself for hydraulic control transmission, pressure lubrication, oil burner feed supplies, accurate metering processes, and other applications.

The whole range of Savery Pumps is British made throughout.

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ASTRONOMICAL ACCURACY

By courtesy of the Mount Wilson and Palomar observatories

NEW 74 INCH REFLECTING TELESCOPE

This large Telescope manufactured by the Sir Howard Grubb Parsons Company, is for the Okayama Astrophysical Observatory which is a branch of the Japanese Tokyo Astronomical Observatory, and will be one of the largest ever to be erected in Asia.

The main optical component, a parabolic glass mirror, collects light from distant stars and focuses it either on to a photographic plate or on to a slit of the spectroscope. The mirror weighs about 11 tons and is 74 inches in diameter.

Fifty tons of complex mechanisms can be put into motion by push button control and direct the Telescope with such precision that a star image of no more than one thousandth of an inch is produced, and then held steady on the photographic plate to less than one thousandth of an inch for some hours. This is equivalent to a pointing accuracy of an orange 20 miles away.

176 HOFFMANN BEARINGS
AND 300 HOFFMANN STEEL BALLS
CONTRIBUTE TO THIS ACCURACY

The Hoffmann Manufacturing Company have supplied the main Polar Axis bearings and many smaller bearings on other moving parts of the Telescope. The diversity of these applications amply justifies our claim for the suitability, efficiency and dependability of Hoffmann bearings.

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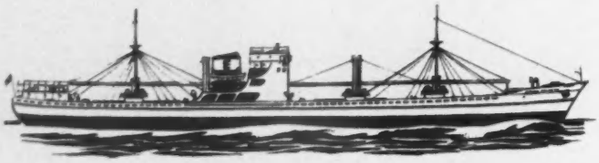
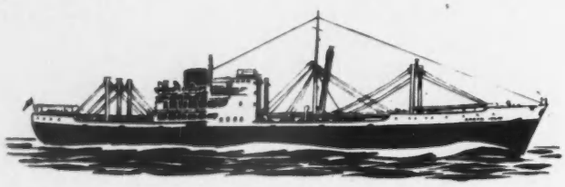


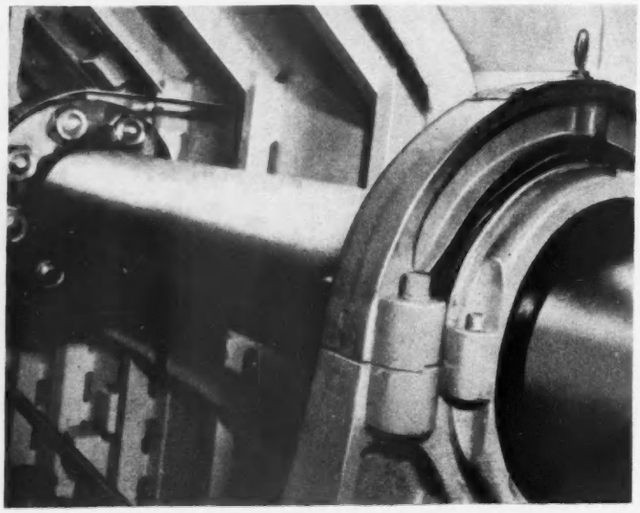


down to the sea with Coopers....

And no difficulty, for you will find Cooper Split Roller Bearings in more than 700 ships – including vessels of H.M. Navy. And those nautical Coopers earn their keep handsomely. Use them on tunnel shafting, for example, and you cut out between 30% and 80% of the power-loss caused by friction with plain bearings.

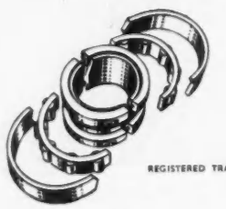
Coopers are particularly easy to keep shipshape. They are fully self-aligning and run cool under all conditions. Just an occasional shot with a grease gun is all they need. You can even inspect the rolling surfaces without disturbing the shaft. When you sign on a Cooper you can be sure of long and reliable service – and the initial cost compares favourably with any alternative.

Cooper Split Roller Bearings are made in sizes from 1½" to 30" bore, (English and Metric Units), complete with fully self-aligning pedestals. And since they are split right down to the shaft, you can fit them with equal ease to shafting with solid forged couplings. If you would like to have further details of how Cooper Split Roller Bearings reduce operational costs, **please get in touch with our Marine Department.**



COOPER ROLLER BEARINGS

split right down to the shaft



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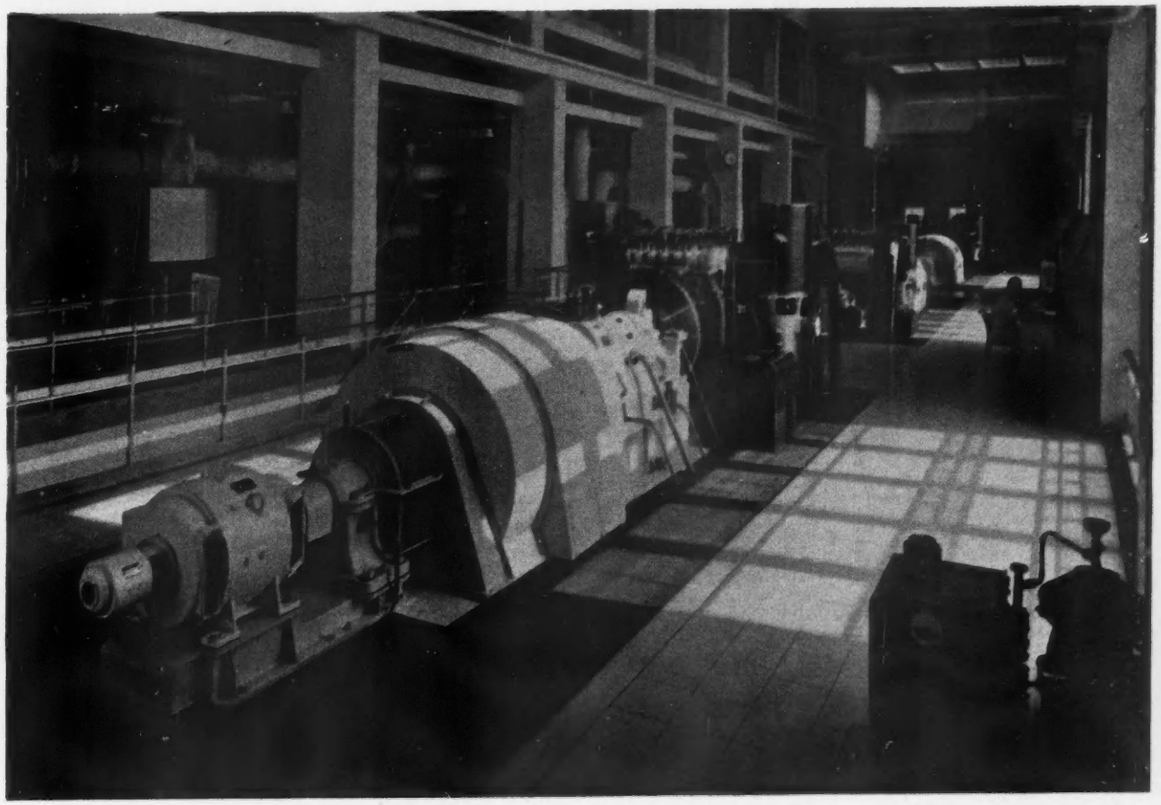

Two 4520 kW Back-pressure, and two 2500 kW Extraction Back-pressure turbine-generators are installed at the Merseyside Power Station of Lever Brothers, Port Sunlight, Ltd.

They are driven by the steam generated for process work and, operating in parallel with the National Grid, provide the electricity for the factory, helping to minimise overall fuel costs.

Extensive experience in the design and manufacture of extraction and back-pressure turbines enables AEI to advise on applications in your particular industry. For further particulars write to AEI Turbine-Generator Division, Rugby or your local AEI office.

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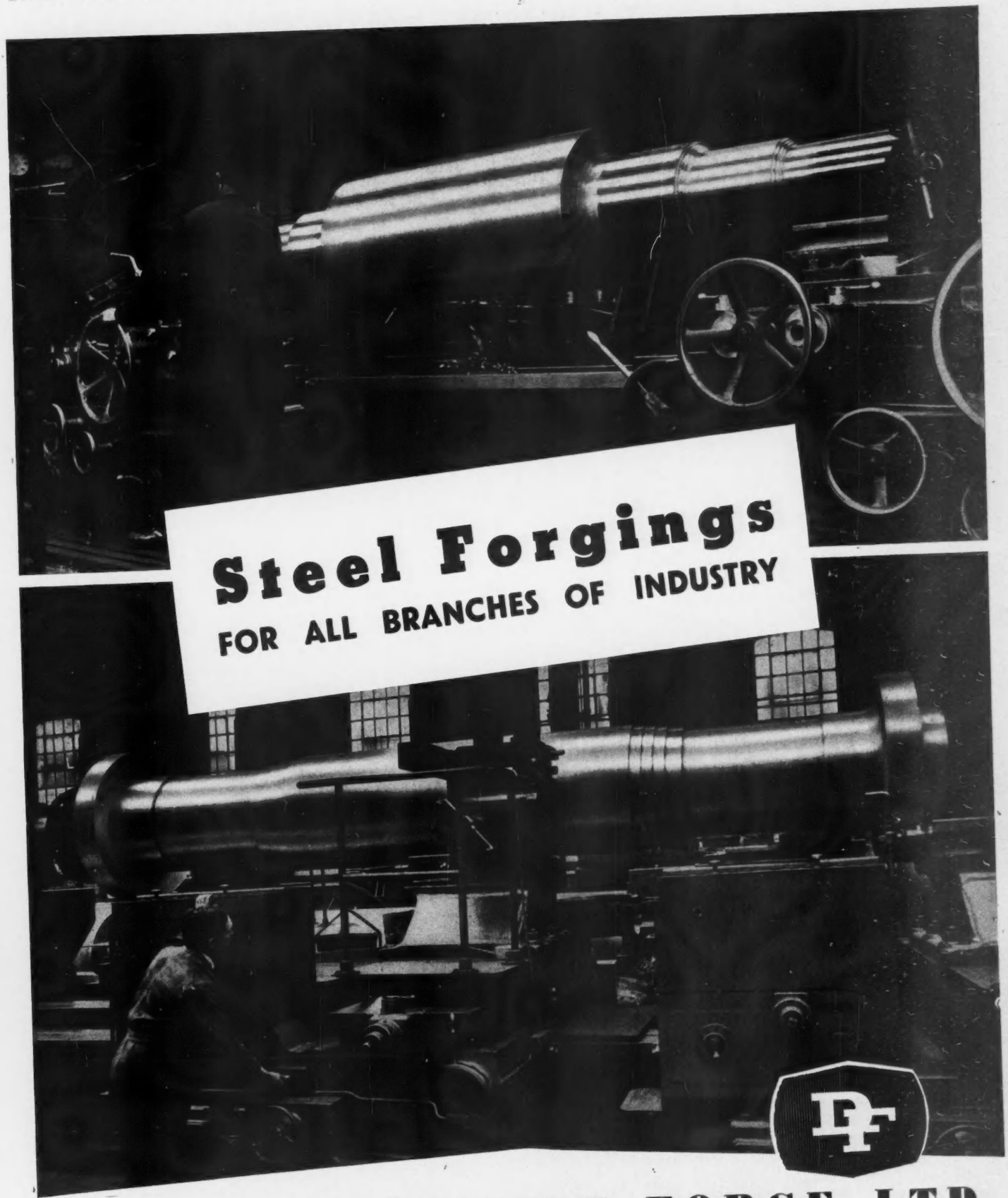

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"BROOMWADE" Air Compressors have a reputation second to none among aircraft manufacturers. They are aware of their RELIABILITY and high efficiency coupled with economic performance. Meticulous care is taken with regard to design and material to ensure a long working life and low maintenance.

The same can be said of "BROOMWADE" Pneumatic Tools and the fact that they are extensively used in this industry is a testimony of their quality and efficiency.

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Our works-trained Representatives will be glad to advise you on your compressed air problems.

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"ARO-BROOMWADE" Type 7512 lightweight drill. Speed 3000 r.p.m. Incorporating the latest refinements and specially designed for the aircraft industry.

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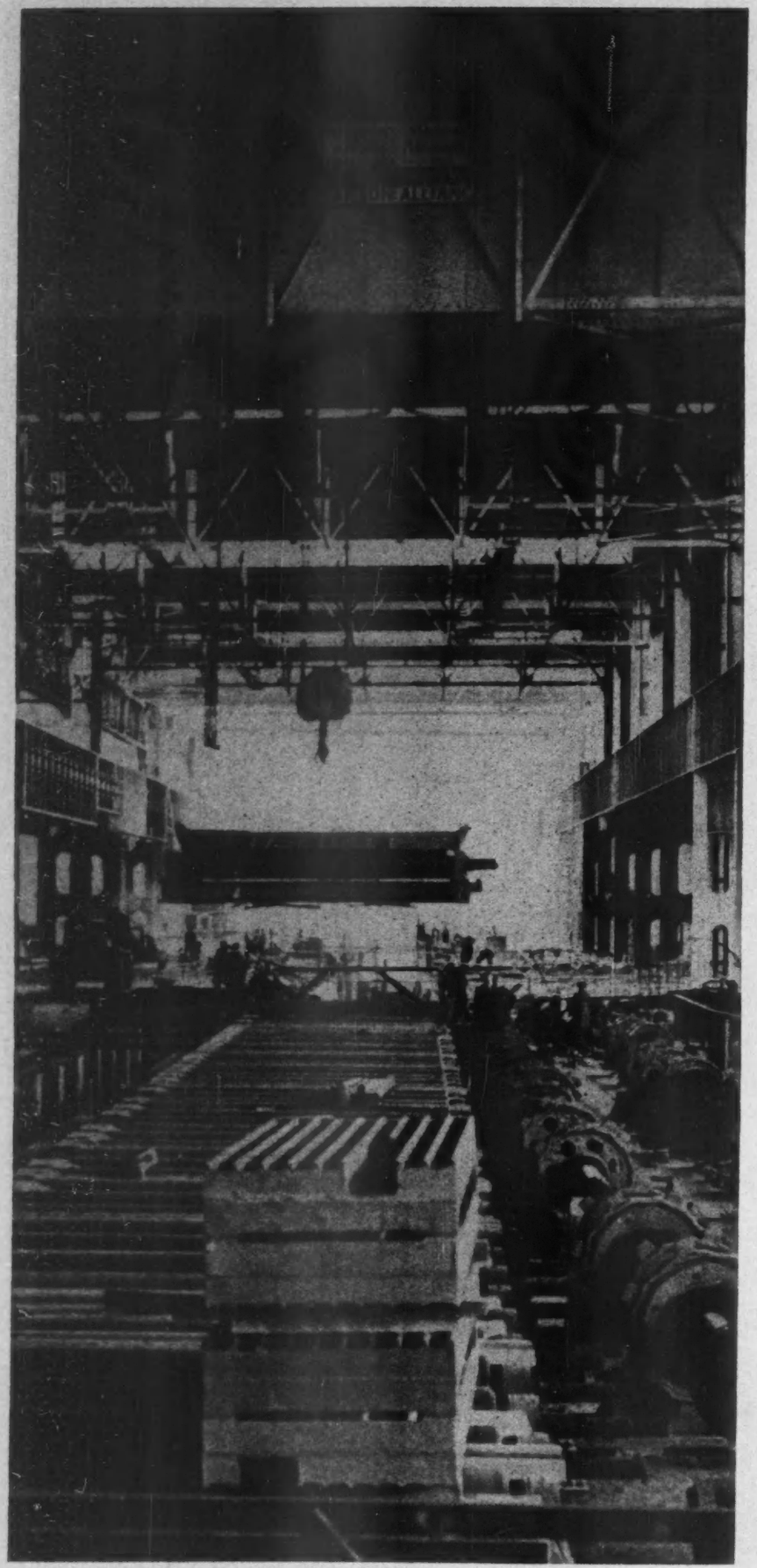

A 150 ton overhead crane about to lower one set of hot leveller run-out table rolls into position. The mill-stand will go at the end of this view. The cooling banks are on the left.

Britain's latest 4-high Plate Mill

A progress report from Consett

THERE is no change in the Consett skyline by which to measure the immense developments going on there.

Below the crest of the ridge, on a huge platform cut in the hillside, Britain's latest plate mill is taking shape. Nearly half-a-mile long and designed after intensive study of American and Continental practice, it will be one of the most up-to-date steel mills in the world.

Even at dawn there are men working there. Work is pressing on fast. Most of the roof is on and everywhere there are orderly piles of equipment which the overhead cranes are moving into position. Run-out tables and cooling banks are all ready, and both the re-heating furnace and the scale pit are almost complete. Some of the shears, the biggest of which can cut through nearly 2″ thickness of steel, are already installed and they are making good progress on the 4-high mill-stand itself.

Consett's new mill is designed to produce 10,000 tons a week of the best steel plates obtainable anywhere, up to 120″ wide and 90′ long and rolled to the tightest tolerances. Britain's position in the world markets will be much reinforced when it starts rolling later this year.

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IRON COMPANY LIMITED

CONSETT · COUNTY DURHAM
TELEPHONE: CONSETT 341 (12 LINES)
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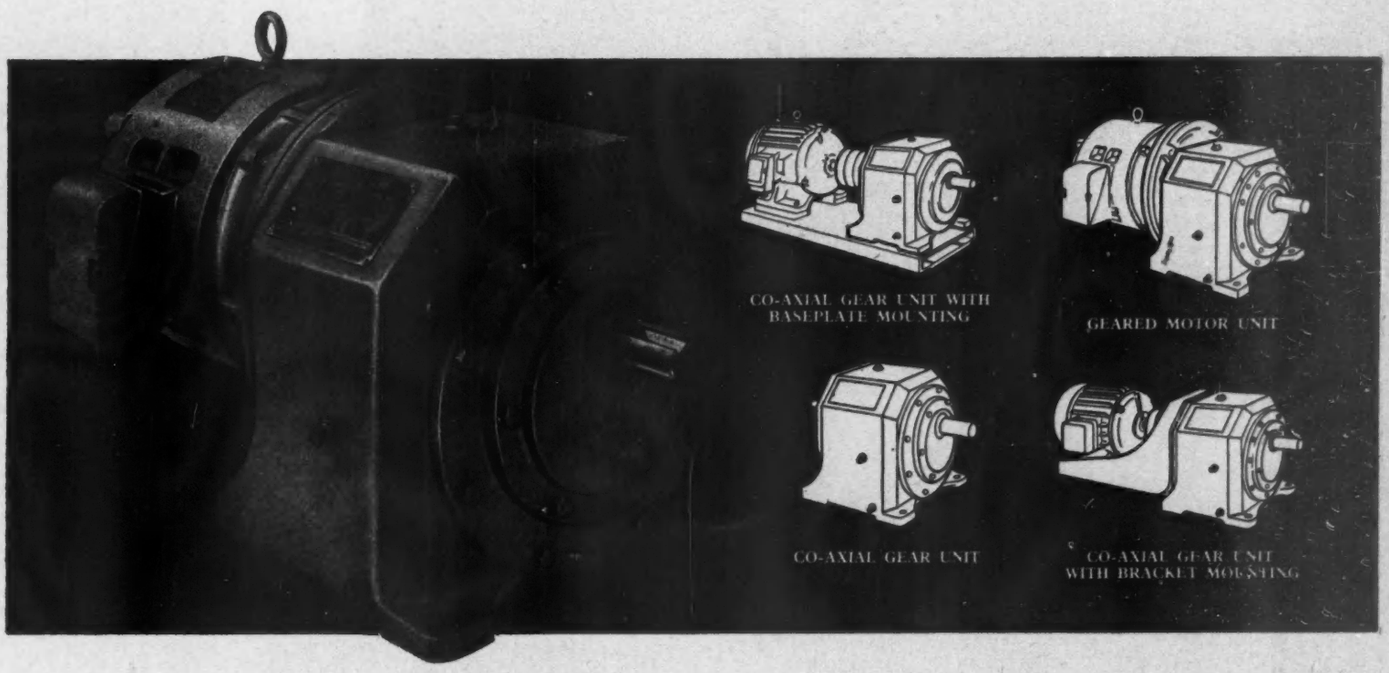
TO-DAY'S MOST ADVANCED GEARED MOTOR UNIT


CO-AXIAL GEAR UNIT WITH BASEPLATE MOUNTING
GEARED MOTOR UNIT
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Helicon geared motors and co-axial geared units are new . . . and all the better for being made by David Brown, the firm with 100 years' experience of gears. That means greater accuracy more reliability with less maintenance — in fact a quiet, compact, sturdy, quality product.

There is a booklet No. F. 444.3 waiting for you. It tells about the range of units covering 34 standard ratios for any drive up to 40 h.p. Write for it to-day.

HELICON

geared motors and co-axial geared units

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100 YEARS 1860-1960

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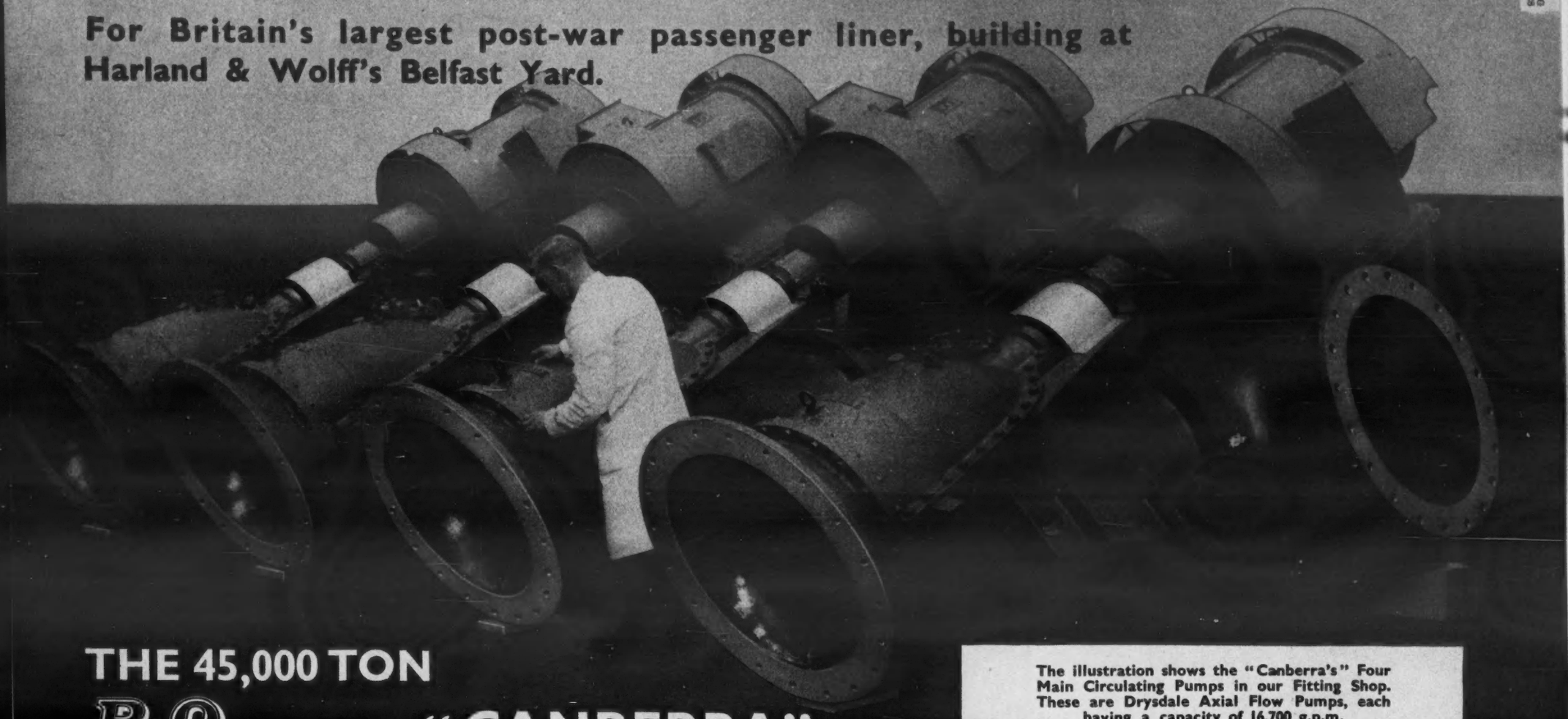
RADICON DIVISION · PARK WORKS, HUDDERSFIELD · Telephone: 3500

DRYSDALE PUMPS

For Britain's largest post-war passenger liner, building at Harland & Wolff's Belfast Yard.



THE 45,000 TON P&O VESSEL "CANBERRA"

The illustration shows the "Canberra's" Four Main Circulating Pumps in our Fitting Shop. These are Drysdale Axial Flow Pumps, each having a capacity of 16,700 g.p.m.

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ENGINEERING 25 MARCH 1960

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The new AIRSCREW MINOR FAN is the quick solution for most ventilating problems. Moving more than 450 cubic feet of air a minute, it is eminently suitable for many ventilation purposes in industry, offices, public buildings and the home. An AIRSCREW MINOR is economical, quickly fitted, reliable over long periods with no maintenance; and *low in price.* Alternative arrangements available with circular or square mounting flange for panel and duct mounting.

Airscrew "Minor"

AXIAL FLOW FAN

Casing Diameter 10·4". Depth 3·8".
Shaded pole motor;
1300 r.p.m. consumption 40W.
No electrical interference.
Dynamically balanced rotor runs in oversize bronze bearings.
All steel parts fully rustproofed.
Can be mounted at any angle.

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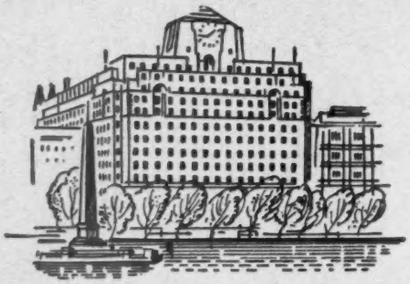
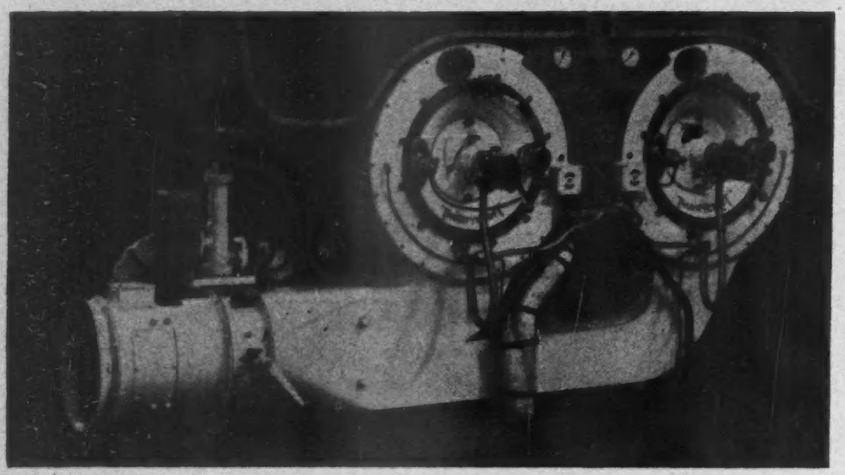
have installed

THORNYCROFT



PRESSURE JET OIL BURNERS at SHELL-MEX HOUSE



Thornycroft equipment has been chosen to illustrate pressure jet type burners fitted to an Economic boiler in the demonstration boiler house at Shell-Mex House.

These burners operate at an oil-pressure of 500 lbs. per sq. in. Recent installations include those at Glaxo Laboratories Ltd., several for the Ministry of Works, Selfridges and London Airport.

Illustrated left:
the pressure jet type installation.

Write for further particulars to:—

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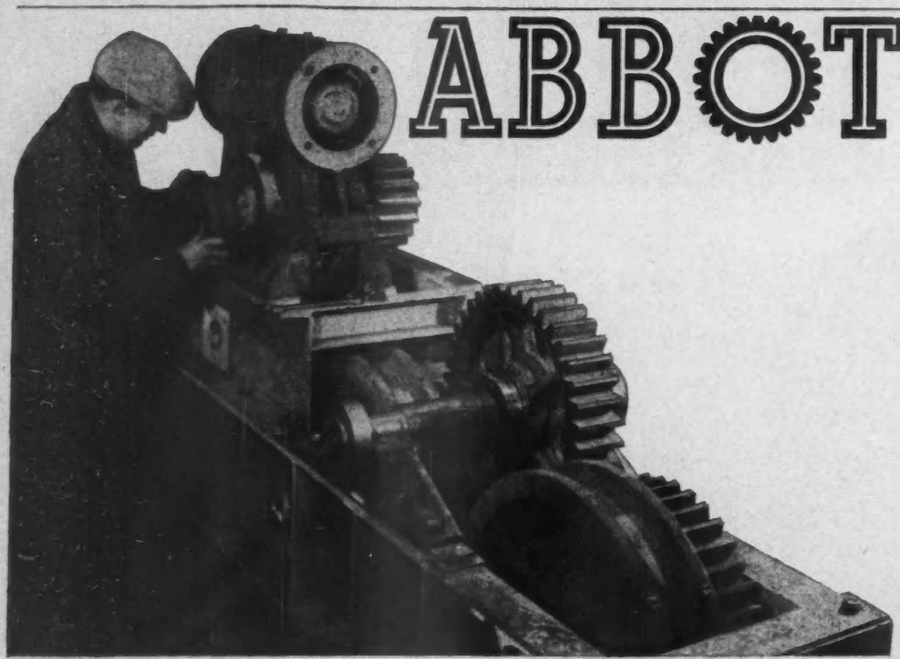

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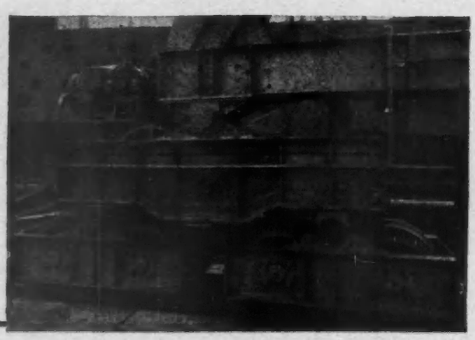

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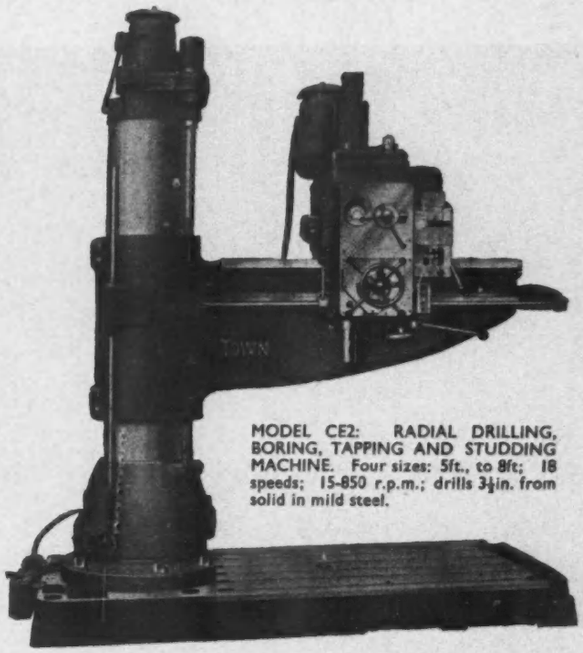
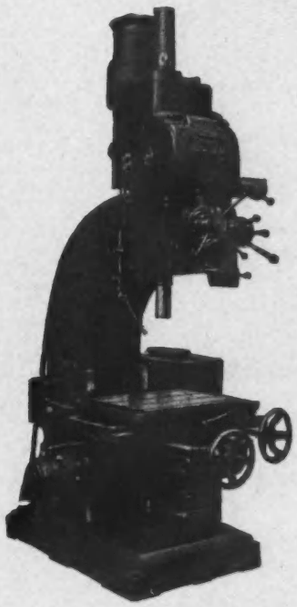
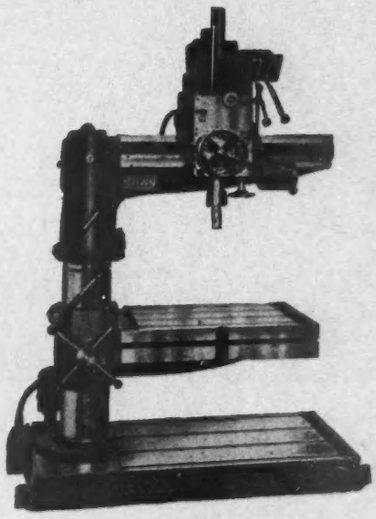


MODEL CE2: RADIAL DRILLING, BORING, TAPPING AND STUDDING MACHINE. Four sizes: 5ft., to 8ft; 18 speeds; 15-850 r.p.m.; drills 3¼in. from solid in mild steel.

MODEL AE4: RADIAL DRILLING, BORING, TAPPING and STUDDING MACHINE. Seven sizes: 3ft. 6in., to 8ft.; drills 3in. from solid in mild steel.



MODEL AE2: VERTICAL DRILLING MACHINE (Heavy duty model). Two sizes: 36in. and 42in.; drills 3½in. from solid in mild steel.



MODEL AE5: RADIAL DRILLING, TAPPING and STUDDING MACHINE. 42in.; drills 1¾in. from solid in mild steel or 1½in. in cast iron.

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are detailed in a folder 'GO TO TOWN' which is available on request. Variations on the standard range can be undertaken, and examples are also illustrated in the folder.

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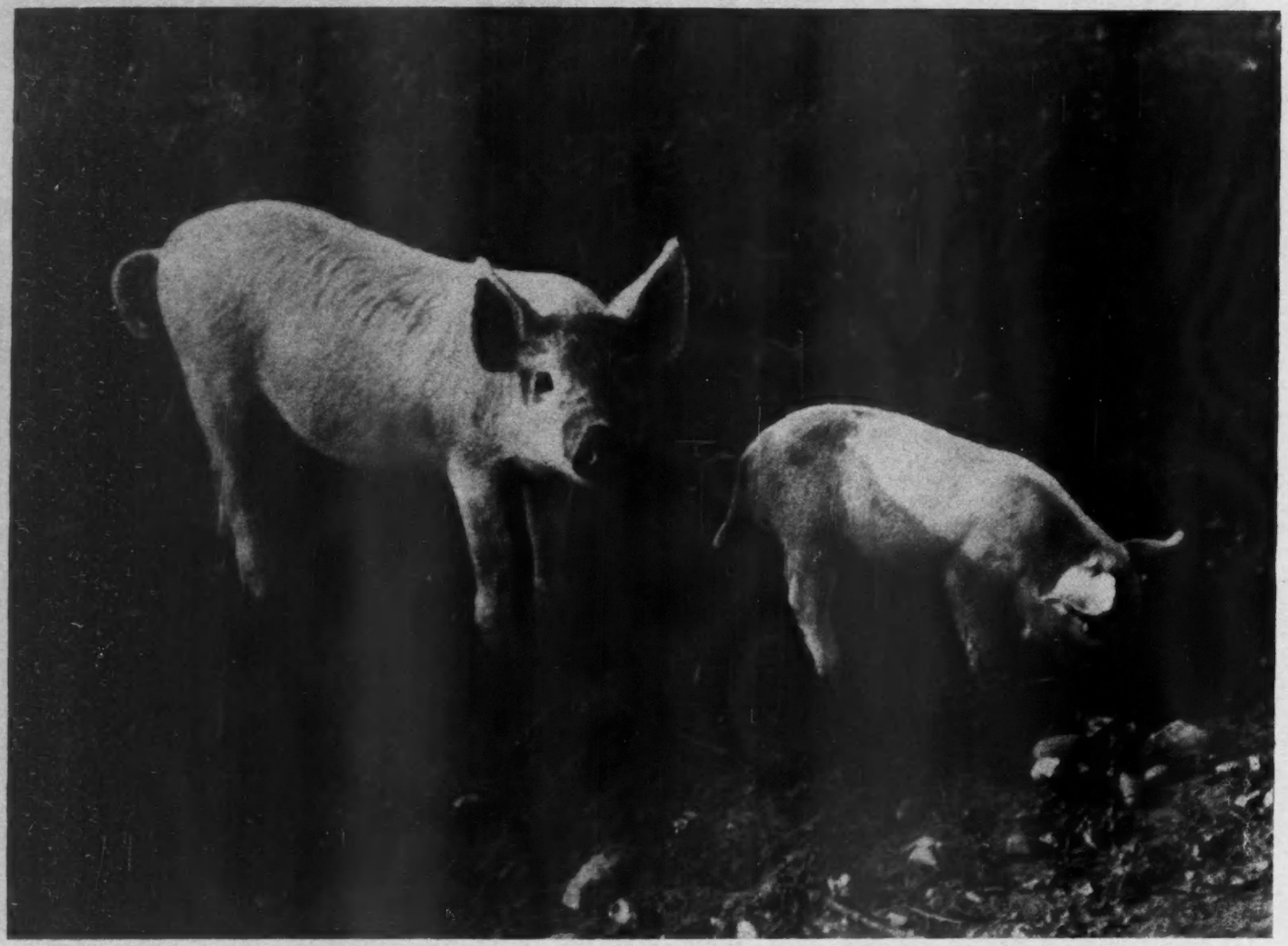

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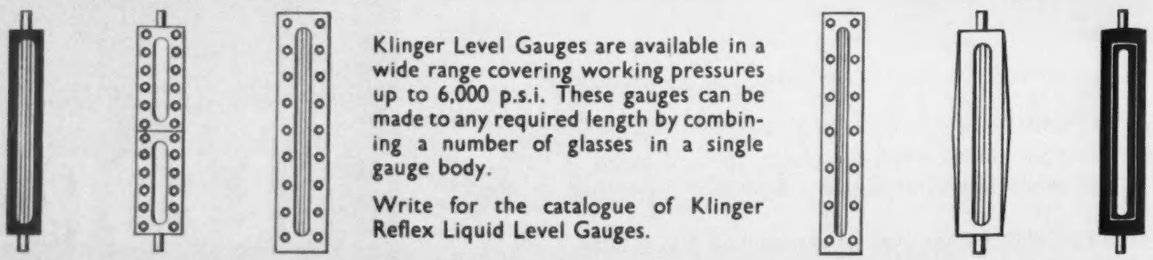

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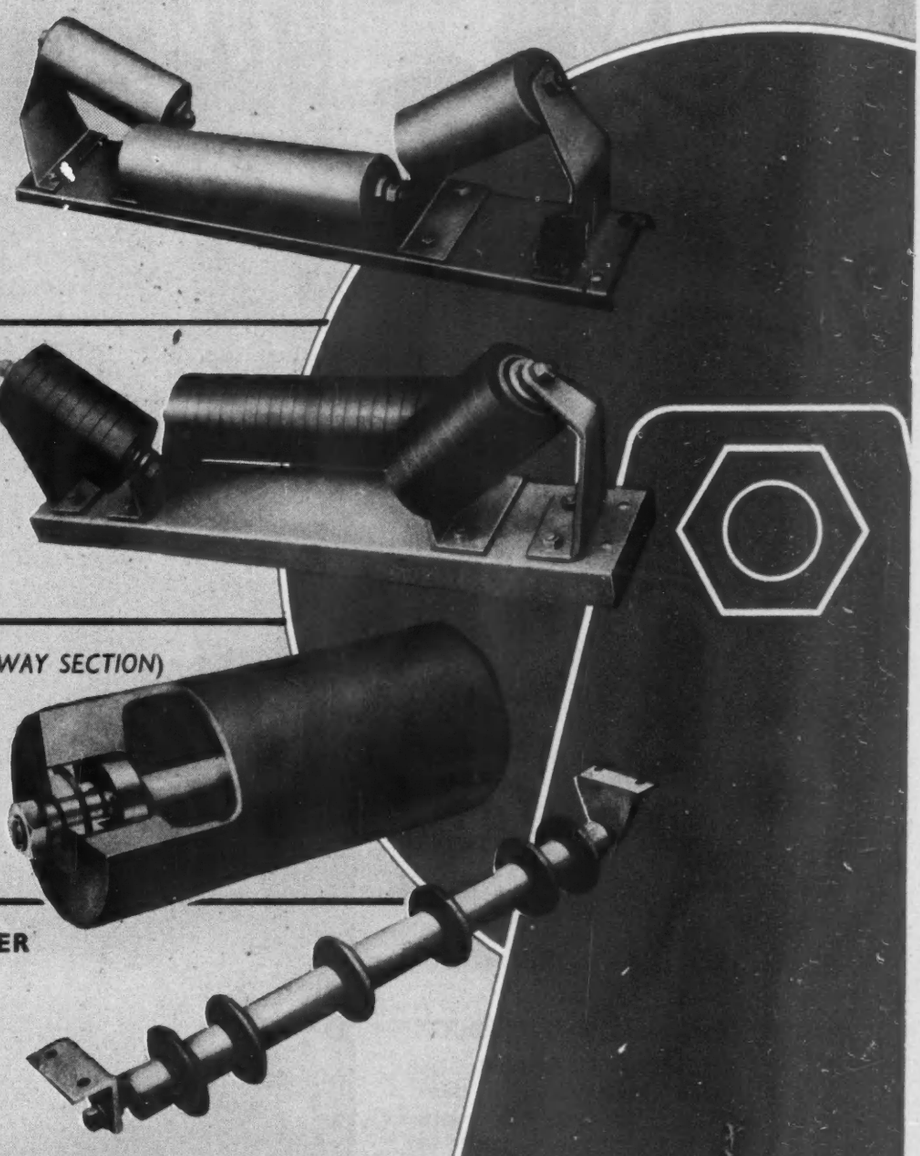

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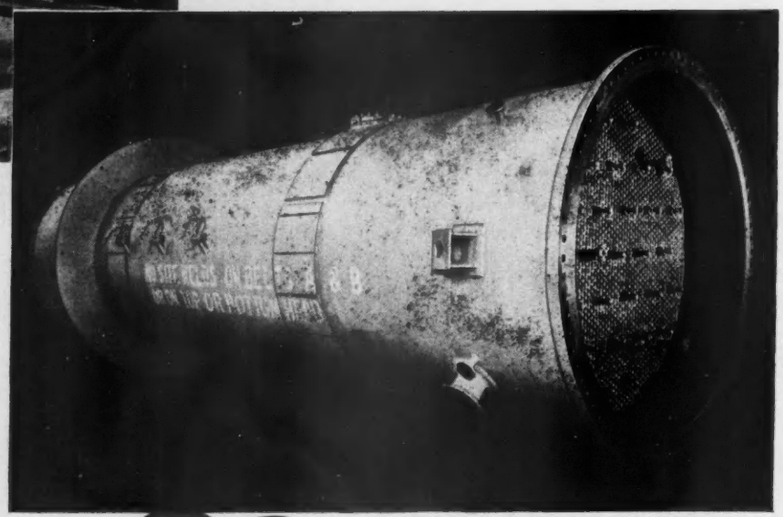

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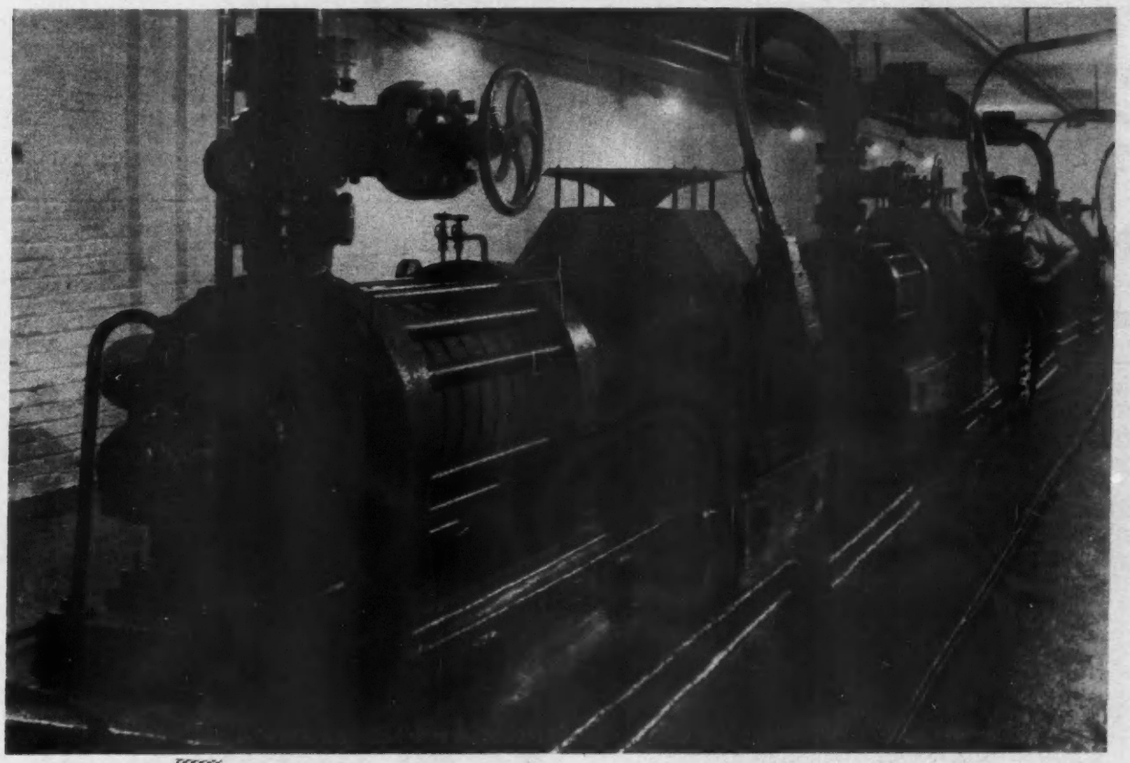

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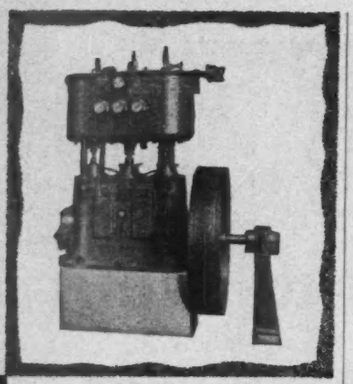

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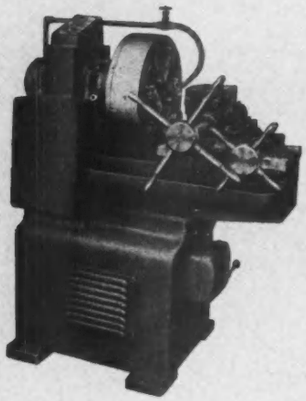

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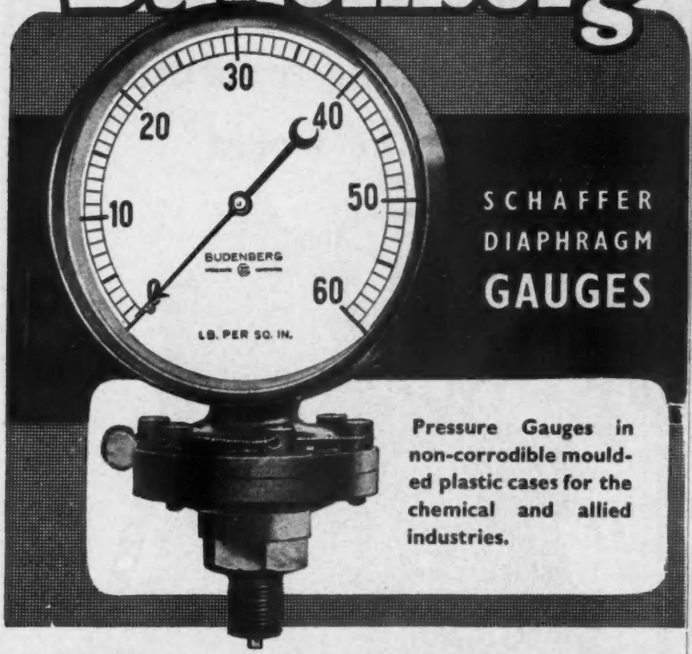

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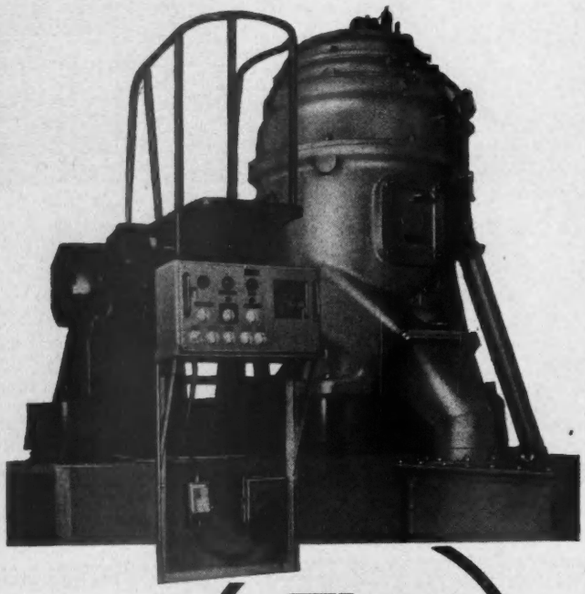

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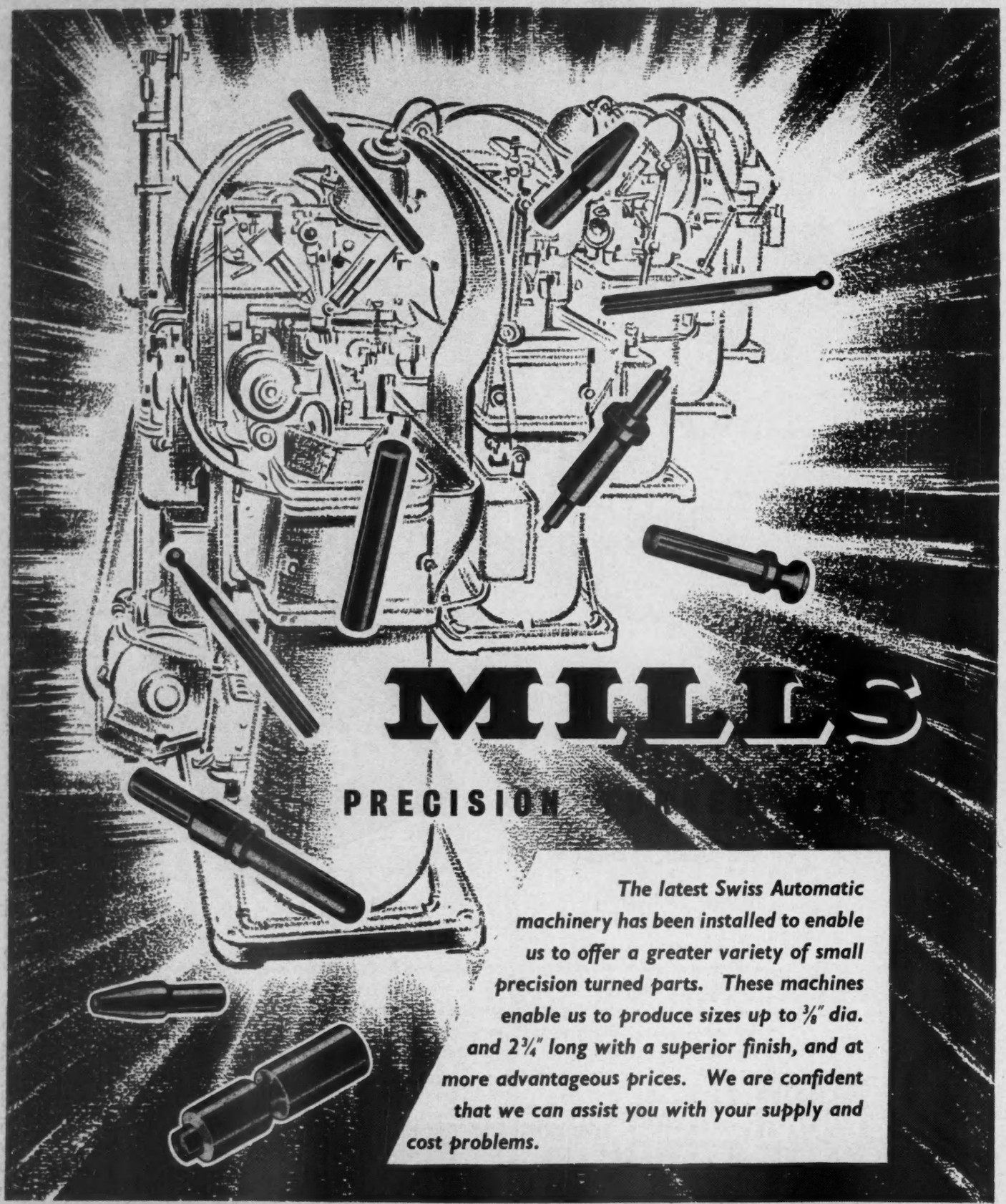
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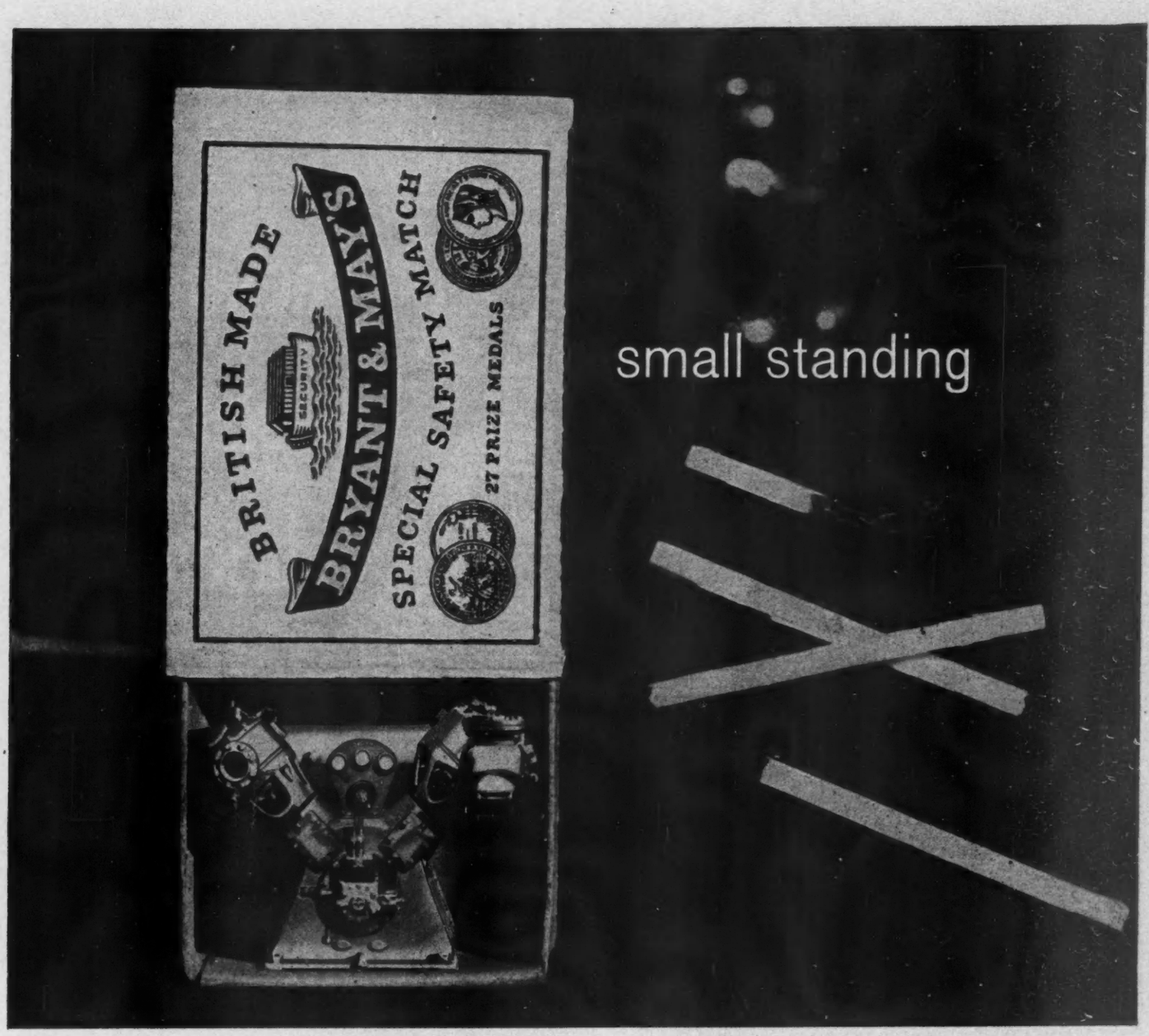

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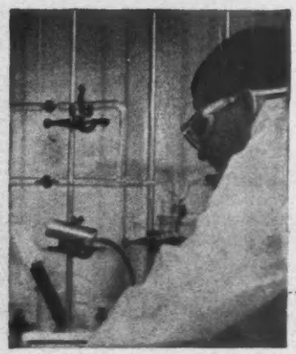


A Wakefield-Dick research chemist investigating the effects of radiation on lubricants.

Two examples of the NUCLEOL range

NUCLEOL 522 A radiation resistant lubricant based on selected mineral oils of high aromaticity and containing special inhibitors.

NUCLEOL G122 A grease gelled with a new compound, and specially inhibited. Designed for the lubrication of control actuator bearings operating at the lower radiation levels.

ENGINEERING Impact

of Competition in Mining Machinery

COAL now has to be sold in a very tough competitive field. Nobody knows this better than the National Coal Board.

As Sir James Bowman, chairman of the NCB, said at the annual Conference of the National Association of Colliery Managers, the basic role of carbon in the future of civilisation will continue, but the pattern of use of different forms of carbon is changing. What contribution the coal industry will make will depend increasingly on its ability to respond to changed conditions and to compete effectively with other fuels.

In the pits the emphasis will be on the exploitation of new mining techniques and on the improvement of old ones; on the surface, better preparation machinery will be the aim. The influence of changing conditions in the fuel supply pattern does not end at the pithead; in some ways it only starts there. Competitive prices, correct and consistent screening, sizing and cleaning of coal really add up to productivity, and this in turn means, in a large measure, better colliery machinery.

So it is not only the coal industry which is faced with a challenge. The mining machinery makers have an equal one. Given the right machines the colliery management has the responsibility of seeing that they are used to the best advantage, and in that, perhaps, lies the most intriguing challenge of all. It is a management, human and technical problem in which the technician has the best chance of success. Can engineers design machinery which, intrinsically, can only work in the best possible way? It is a tall order, but it would be foolish to deny the possibility. Not so long ago the automatic factory existed only in the minds of a few fanciful dreamers. Now it is here. Is the automatic coal mine an impossibility?

Two Leads in Prestressed Concrete

The Medway bridge is to be of prestressed concrete. It will be the largest bridge of its kind—cantilever girders with a suspended span in prestressed concrete—in the world: the clear span above the river will be 500 ft, nearly 100 ft more than the next largest, that at Coblenz over the Moselle in Germany.

The decision to go ahead in prestressed concrete reflects two considerations. First it confirms the lead British engineers now have in the use of prestressed concrete. Though of peculiarly continental origin, it is from Britain that most of the improvements have come during the last ten years.

Second, it marks the progress that prestressed concrete is making. A few years ago such a design as that for the Medway bridge must have been carried through in steel. Indeed, on behalf of the Ministry of Transport, the consultants, prepared three designs, two in steel and one in prestressed concrete. That the successful bid is in prestressed concrete reflects the greater amount of research being done on concrete than on steel. There is also the fact that concrete is more fashionable than steel. Only suspension bridges seem a field secure to steel, and even there—at Tancarville—the towers have been built in concrete.

Some details of the Medway bridge are given elsewhere in this issue.

Mr. Amory's Restrictions on Hire Purchase

No sooner does the Federation of British Industries reveal that shortage of labour is a limiting factor to expansion than it is learned that the home market for domestic appliances is not as good as it was.

In fact, the gentle credit squeeze applied last April by Mr. Amory, the Chancellor of the Exchequer, has brought down the demand for electric household machines to the point where the Hoover company has to sack one in ten of its labour force.

Washing machines and refrigerators are labour saving, even money saving and certainly pleasing to possess. But the British home that buys these things is consuming effort in three different directions at once. It is using raw materials that are as scarce for the export effort as for the home manufacturer. Likewise it is using the time of a worker whose product can be sold abroad. And by no means least, it is almost certain to be using credit which could be better going into capital investment.

Death of a Pioneer

The disappearance of Armstrong Siddeley cars is not just the sad end of a splendid tradition and a fine line of cars. It is a sign that the facts of life in the car business are every bit as tough as in aircraft. And that the tide is running against the specialist car.

The factors telling for the very biggest battalions in the motor industry are numerous and subtle. The public is a reading animal and it knows that many of the new cars and perhaps most of the grander limousines are company owned or expense-sheet maintained.

Against this background the social value of the type to which the driver has attained loses some of its power. It has long been the claim of those popular car owners who leave the bit-under-the-bonnet to the garage that they are interested only in transportation—not in motoring as an art.

For them the big producers can turn out more "car per pound" and whatever the jibes about quality the running costs of their products are probably less severe. What if the engine of the mass-advertised car seizes up on the road and becomes a ruin? So long as the AA tows the so-called car to a competent garage before lunch the owner will be able to drive off again that evening with a new engine at no more cost than an overhaul for the engine of the £2,500 saloon.

Against the ending of the Armstrong Siddeley line of cars, the sale of the Daimler firm, the disappearance since the war of Lanchester and Jowett must be set the supremely confident rise of the Jaguar car.

There can be no easy answer to this or there would be more than one Sir William Lyons. What the Jaguar stable thrives upon appears to be dedication. To racing performance, to an extremely difficult to achieve simplicity of styling, and to nothing else but Jaguar cars.

of Attenuating Nuclear Power

To judge from recent statements by the chairmen of the nuclear consortia, the cut-back in Britain's atomic energy programme will bring nothing but relief. But the losses of these companies in building nuclear power stations are no argument against nuclear power; they are merely an indication that the Government has not assumed a sufficient measure of the financial risk in developing so new and uncertain a source of energy.

The nuclear power programme, according to the White Paper, is to be halved, with a total nuclear capacity of about 5,000 MW by 1968, instead of 6,000 MW by 1966. The number of stations built will further diminish (from 12 or 14 to 7 or 8) as a result of increased unit rating. During the next seven years the capital expenditure on electrical generating stations will be reduced by £90 million.

But is this economy the sole object of the cut? If so it is a most hazardous decision. Admittedly there is a temporary glut of coal and oil. But such a surplus was presumably unforeseen; might it not disappear as quietly as it came. The planners were wrong before; could they not be wrong again? It is stated that the earlier forecast of electricity requirements has proved to be an over-estimate. How can such a statement be supported? The time to which the estimate applied has not yet overtaken us. It is a further sign that Britain is concentrating too much of her treasure on immediate delights and too little on her future.

To cut the programme solely as a financial saving is to be oblivious of technical (and national) considerations. W. L. Budge and B. L. Lloyd of the Westinghouse Electric Corporation, writing in the Canadian *Modern Power and Engineering*, have demonstrated using a zero-initial or "Arabian Desert" model, that there is an, optimum combination of conventional and nuclear plant. Capital and running costs fall to a minimum at a given ratio of the two capacities. Would this not have been a better basis on which to revise the British programme?

One brighter aspect of the cut. Perhaps the manufacturing resources left idle by this slowdown will be diverted to the atomic export trade, and hence to those smaller nuclear reactors which are best designed to serve it.

Research that Pays Off

A Canadian who has made a study of research policies in Europe, including the United Kingdom, praises the National Research Development Corporation in this country for the good work it is doing in helping to apply the results of scientific research. He is Mr. D. Wilfress, former head of the Canadian delegation to the Organisation for European Economic Co-operation, and his report has been presented to the secretary-general of OEC.

He says that the NRDC's example could be studied with profit by other countries. The British people, he considers, were greatly helped in becoming "science minded" by the important part that science played in their war effort. He also sees the research associations, which originated in our Government's attitude to research during the First World War, as worthy of study and emulation by other European countries.

But there are still some important steps that should be taken in Britain, just as much as in Europe generally. Sponsored research, for example. Canadian experience has shown that whenever there is a close connection between a private firm and a particular research project, no difficulty arises in exploiting the results of the research which the firm regards as being due to their own initiative. The reason that sufficient importance has not been attached to sponsored research in Europe is, he believes, because the emphasis here has always been on fundamental research. "Throughout Europe pride of place is given to fundamental research."

His main conclusion is that European countries must develop cooperation in scientific research. It must be promoted for economic reasons in order that Europe may retain its relative position in the world economy. More attention must be paid to applied research. Each country should draw up a national science policy. University and technical college teachers should be encouraged to do sponsored research.

"Europe," he believes, "is now in a position to move forward."

and Six and Seven still not Thirteen

The 20-member trade talks in Paris lost no time in discovering that the six nations of the European Common Market are not interested in a *detente* with the seven of the British led European Free Trade Area.

This swings British industry back to an even greater dependence on the successful outcome of the September conference in Geneva on the General Agreement on Tariffs and Trade.

Outstanding in importance among United Kingdom hopes from the Geneva talks will be the immediate future of United States tariffs. The Government has let it be known that Britain would willingly make tariff reduction agreements, but it will be no easy matter for the United States.

They have something of a dilemma. Foreign exports into their home market are expanding and there are vocal lobbies to express the home manufacturers' unfavourable opinions. At the same time, Mr. Khrushchev grins most happily when he is promising economic war—and allies are better kept with trade than aid.

It remains to be seen what effect the British Trade Fair in New York has upon Anglo-American trade. Perhaps the greater part depends on the readiness of British manufacturers to follow through. With the going in Europe destined to get tougher and tougher as the Common Market's internal tariffs drop, the success of British exports to the US will become more vital.

Wind-on Tapes Stop Pipeline Corrosion

Tape makers are preparing for the large potential demand for self-adhesive pipeline wraps. They are particularly cheap when applied mechanically on both long and short runs.

IF YOU were an American engineer with even a suggestion of responsibility for pipes or pipeline protection, chances are you would have been sold with the idea of using ready-made plastic tapes. Just wrap them on . . No more mess with hot tar mixes or bitumen, and a product which offers savings over traditional coatings with less maintenance.

This is not intended to be an advertisement. But it is well worth looking at the advantages of such protection before shrugging it off and putting the clock back another ten years.

Makers of tapes in this country look forward to opening up the market for heavy-duty wraps in the near future, though there is very little activity at the moment in a commercial sense. Gosheron took the lead to establish a pvc tape which has caught on in a limited sense, and the illustration, top right, shows one of their successes in which North Thames Gas Board applied their tape to a 6 in liquid products pipeline running between Dagenham and Beckton. The tape used here was Polyvil PP which is a plasticised pvc tape of 0·010 in thickness.

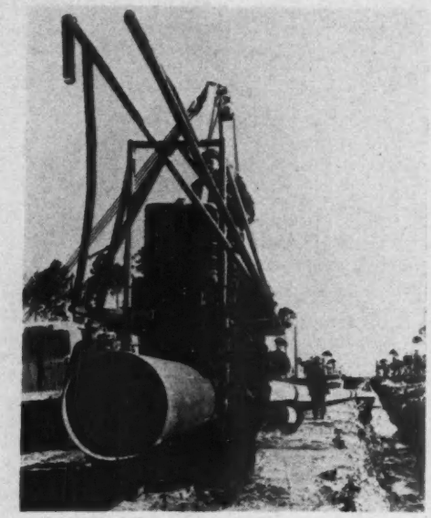
The trend in America seems to be towards use of polyethylene wraps. Union Carbide send news of use of their polyethylene in a major installation (commented on later), while Permacel, Chase and Sons, and the Kendall Company all offer polyethylene tapes in addition to pvc. One gleans from recent advertising that tape companies have great confidence in the future of polyethylene. Chase and Sons comment: " Our firm manufactures polyethylene, pvc and butyl-pvc tapes as well as several score other tapes for various purposes. We chose extruded polyethylene to offer as a pipe coating because we feel that the combination of its economic advantages, plus its several superior product properties, makes it the most universally acceptable material."

In the United Kingdom three leading manufacturers of tapes are moving into the polyethylene field. Gordon and Gotch (Sellotape) are developing one but are unable to say much about it at the moment; Permacel are making arrangements for importation of three American Permacel tapes—two in pvc, the other in polyethylene; and John Gosheron and Company are developing polyethylene but have not officially released it for industrial use.

Choice of pipe-wrap material lies between bitumen bound with paper, cotton or glass fibre tapes, and plastic wraps mentioned above. Pipeline activity in this country is not so highly advanced as in America but there are plenty of long distance gas main, water main and oil pipeline projects to warrant home manufacture of tapes should they be accepted. Yet the oil companies have a natural bias towards use of bitumen. Esso Petroleum, who hope to obtain permission to build a 6 in pipeline from Fawley to Severnside, and another 12 in pipeline from Fawley to London Airport, will be using a double-wrapped bitumen/glass fibre tape protection in which they have great faith.

North Thames Gas Board, who have pioneered use of plastic tape protection in the gas industry, have shown that pvc tape can readily be used for the job of local weld protection as well as for complete on-site wrapping. Just alongside the 6 in pipe mentioned earlier is a 24 in gas main prewrapped with bitumen but protected at the welds with pvc tape.

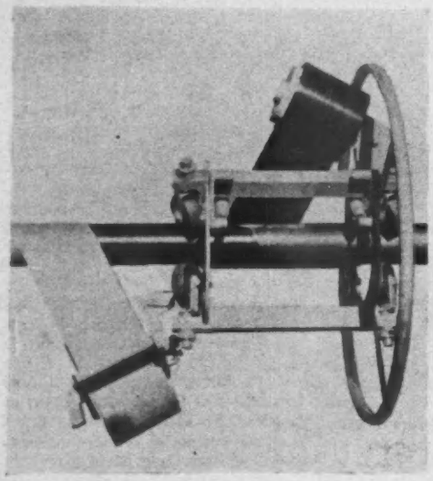
Full benefit from the cleanliness, cheapness, and speed of application of self-adhesive plastic tapes comes when the process is mechanised. Chase and Sons comment that " in a broad general sense, it can be stated, that in the smaller pipe sizes (¼ in IPS to 4 in IPS) tape coating constructions enjoy a total applied cost advantage of about 50 per cent compared with bituminous coatings. As the pipe size increases the margin narrows and appears to stabilise at 80 to 90 per cent at the 20 in IPS. Obviously," they add, " many factors such as logistics, terrain, labour application cost, and others can alter these figures either way in any given instance."

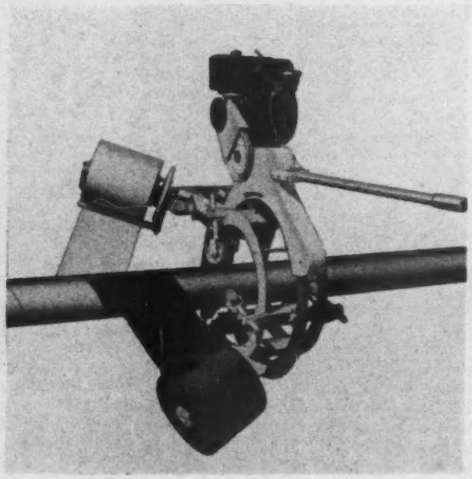


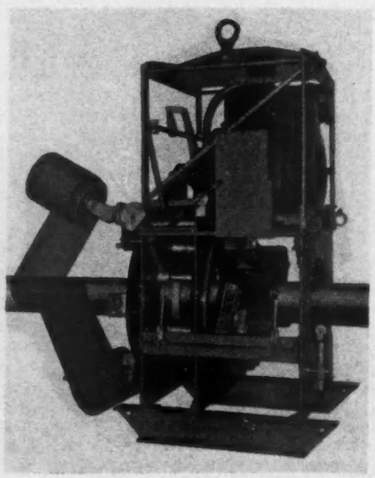
(Left) Polyethylene tape for American pipeline. (Right) Pvc tape for North Thames Gas Board.

The illustration shows machinery employed by Houston Texas Gas and Oil Corporation to preclean and wind polyethylene tape (derived from Union Carbide material) on to 1,616 miles of main and 700 miles of laterals on the Texas-to-Florida natural gas pipeline. Altogether 41 million sq. ft of 0·014 in thick tape were used, applied at the rate of 17,000 pipeline feet per day. Savings over tar coatings were reckoned to be nearly £200 per mile.

American tape manufacturers are also promoting use of their tapes for exposed piping in chemical plant, gasworks and the like. Using mechanised applicators like those shown below (from the range made by the A. E. Betzel Engineering Company in the USA) costs can be competitive with conventional coatings such as tar-epoxies even for short runs. It seems that a little forward thinking along these lines might pay dividends in this country as well.







Applicators for self-adhesive tapes. Left: for pipe ½ to 2½ in dia.; centre: 3·3 h.p. motor driven machine for pipe up to 12 in dia.; right: one with precleaning incorporated.

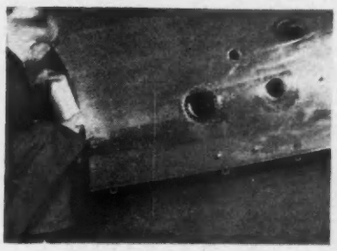
Wide Protective Tape

Better adhesives, and strong, cheap plastic films are regularly being combined to make news. Gordon and Gotch now bring out a vinyl one for protecting surfaces. There are vapour phase inhibitors in it to stop metal corrosion.

The wide range of surfaces to which this can be applied includes polished steel, polished aluminium, anodised aluminium, mild steel, lacquered or painted metals, decorative and industrial plastic laminates, porcelain, glass and some polished wood surfaces.

This transparent unplasticised vinyl film, giving a good measure of pliability, is coated with a low tack adhesive designed to give both ease of removal from all surfaces and long application life.

Protection of polished metal and plastic sur-



faces during manufacturing operations and in storage or transit, is now greatly simplified by this new stick-at-a-touch medium. The tape is not intended to give absolute protection against severe wear and tear and abrasion, but to provide a barrier against scratches, disfiguring marks and scuffing which would make many polished or decorative surfaces unsuitable without expensive refinishing.

The vinyl film is fully water and moisture vapour proof; it also exhibits a high degree of resistance to attack by chemicals, thus offering an all round protection hitherto impossible with conventional tapes.

Vinyl Protection Tape was comprehensively tested in conjunction with a wide range of differing surfaces. These tests brought to light the need for modification of the adhesive. To limit the possibility of rusting on steel surfaces a vapour phase inhibitor was incorporated. A further inhibitor was added to increase the protection against staining on copper, brass, bronze and other copper-containing metals or alloys.

This product has a long indoor storage life—up to nine months—while in contact with the various surfaces mentioned. If exposed to direct weathering for long periods, the tape won't last so long. Transparency of the base film ensures that any printed matter on the protected surface remains readily visible. Additionally it can be printed, should identification or informative symbols be required, with standard flexographic inks.

Standard sizes in the UK will be widths up to 24 in on rolls of 100 or 360 yards.

Gordon and Gotch (Sellotape) Limited, 6-10 Paul Street, London, EC2.

Creep-Resistant Zinc Alloy

In a talk to the American Zinc Institute on "Rolled Zinc Trends," E. H. Klein of the New Jersey Zinc Company discussed a new titanium-zinc alloy which he described as offering greater resistance to creep and grain growth than any rolled zinc alloys developed to date, and now available in the USA at competitive prices.

The titanium-zinc product promises a broad range of new market possibilities, including roofing products, builders' hardware, electrical equipment, automtotive parts, novelties and metal tools in general, Klein stated. In addition, an AZI study is under way investigating the new alloy for lithographic printing plate possibilities.

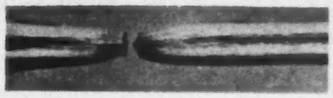
Composition of the new alloy is 0·8 Cu-0·15 Ti-zinc. It combines advantages of commercial rolled zinc with appreciably greater creep resistance, resistance to grain growth at elevated temperatures, and a lower coefficient of expansion. Under a stress of 10,000 lb per sq. in the alloy will extend 1 per cent every 13 years at 25° C (10^{-7} per hr at about 5 ton per sq. in).

Developed by the New Jersey Zinc Company, the new alloy has been rolled and formed into leaders and gutters under AZI auspices. After a year of exposure, these show no perceptible sagging on any reasonable hanger spacing.

Super-Pure Chromium

Using the currently favoured method of preparing chromium from decomposition of the iodide, Chromalloy Corporation can now offer metal of 99·997 per cent purity. It contains no single metallic or gaseous impurity in quantities greater than 10 parts per million.

Chromalloy use the decomposition process developed by Battelle Memorial Institute which is also exploited by the Materials Research Laboratory of the DSIR in Australia, the recognised leaders in chromium technology. The American company's contribution should not, however, be underrated. In preliminary reports, their Iochrome has displayed substantial ductility—44 per cent elongation and 78 per cent reduction in area in room temperature tensile tests on wrought material from an arc-cast ingot



as illustrated (although no indication is given of dimensions).

Many attempts have been made to increase the chromium content of super alloys used for high temperature service but the alloys generally become more and more difficult to work. Chromalloy have demonstrated that alloys approximating to 55Cr-nickel, 50Cr-nickel, 30Cr-nickel- and 20Cr-nickel compositions can be hot rolled without sign of edge cracking or disintegration, where similar alloys made with electrolytic chromium were unsatisfactory.

Many organisations are actively developing chromium alloys which would be expected to offer good high temperature properties with high oxidation resistance. But the metal is dogged by brittle fracture troubles. Nitrogen and oxygen have a particularly noticeable effect and it is difficult to see them maintained at low enough levels once it is attempted to cast commercially useful ingots, even with a source material such as Iochrome.

Chromalloy Corporation, White Plains, New York, USA.

Protection for Propeller and Compressor Blades

An article in the April issue of *De Havilland Gazette* describes a coating procedure used by the Propeller company which might prove of wide application. It is based on a Rokide flame-sprayed coating of alumina.

Aim of the work was to improve the blade life of aluminium propellers, especially those which suffer severe erosion during reverse-thrust landings. The coating formulation is based on the principle that a hard layer is capable of deflecting particles which strike the surfaces obliquely. There is still no complete answer to erosion of the leading edges. Well established among the hard coatings is a fine-grain nickel coating which can be applied by electrodeposition over a layer of rubber. First difficulties associated with lightning burns were eliminated in this coating method by making the rubber conductive, but the high cost of about 20 per cent blade cost persuaded the company to look at other methods.

Porous Rokide coatings on aluminium presented a corrosion problem, though not very severe. So it was decided to use an underlay of epoxy resin about 0·005 in thick. Discussions and development with the Norton Grinding Company, makers of the Rokide materials, lead to tests in which glass missiles were fired at the plate specimens at an angle of 8° from a distance of about 1 inch. From these it was deduced that an expoide-aluminium-Rokide epoxide-sandwich construction would be optimum. The final sequence adopted was as follows:

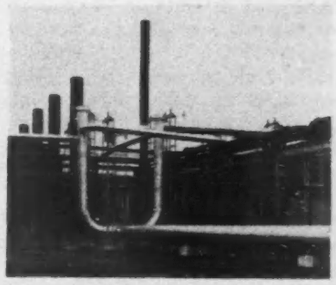
1. Blade surface prepared with an etch primer including a corrosion inhibitor.
2. Primed surface sprayed with epoxide lacquer.
3. Expoxide lacquer dusted with aluminium powder prior to low temperature cure.
4. Dusted and cured surface flame-sprayed with flash of aluminium.
5. Aluminium surface flame-sprayed with Rokide alumina.
6. Rokide surface sprayed with further coats of lacquer and submitted to final low temperature cure.

Blades so protected withstood overload spinning tests to substantiate satisfactory adhesion, and were perfectly protected except on the leading edge when water followed by loads of quartz chippings from one-sixteenth to one-quarter inch diameter were dropped in front of the propeller when it was rotating at 1,000 r.p.m. Total thickness of the sandwich layer was 0·015 in which weighed 6 oz per sq. ft.

Further success was obtained with a simpler layer of epoxide loaded with Rokide alumina powder which could be sprayed straight on to the blade, and weighed only 2 oz per sq. ft for the same thickness.

Aluminium Cladding for Steam Main

Aluminium sheet has been used to clad a steam main at Spondon to give a lasting, maintenance-free protection from the weather. The main, a 30-in bore steel pipe, was installed to tap steam



from a power station and deliver it 2,125 ft for distribution in the British Celanese works. The system also included some 1,300 ft of smaller-bore branch pipes.

All the insulated pipes in the system were protectively finished with Noral 2SH (hard, 99·0 aluminium grade) of 0·036 in thickness supplied in coil form by Northern Aluminium. Seven tons of aluminium were needed in all, but on the largest pipes the cladding weighed only a little over 4 lb per ft and its lightness enabled savings to be made in the supporting structure. The insulating engineers, Thomas Cotton of Mansfield used aluminium because it is economical and easily worked. Lengths of coil were cut to wrap the main circumferentially with a 2 in overlap joined by pop rivets. Adjacent wraps along the length of the pipe also overlapped by 2 in, but a minimum of permanent fastenings was used at this joint to allow for expansion and contraction.

Northern Aluminium Company Limited, Banbury, Oxon.

Plain Words

By Capricorn

BY THE time you read this I hope to have gone along to the International Machine Tool Exhibition with one object uppermost in my mind. I want the answer to a fascinating question. Is it possible to discern national characteristics in engineering designs? And if it is possible to discern such characteristics, is it also possible to define them?

An Italian engineer once made a sacrilegious remark to me to the effect that the Best Car in the World was too heavy, too solid looking for him. He preferred something slim. Maybe he was finding an excuse for the failure of his own country to produce such a splendid *genre* of car, but ever since he startled me with his remark I have looked at all sorts of engineering designs as one would look at old paintings—to try to guess the "school" before looking at the label.

Try it yourself and you will see how difficult it is to guess the nationality of a design, unless you happen to be familiar with the particular class of machine. Motorcars are an obvious subject of study, and few would have difficulty in recognising an American car; but who, seeing a Jeep for the first time, could have guessed that it had come from the same stable as the bulbous hard-tops? If ever a design possessed fitness-for-purpose, it was the Jeep. The designers had acquired the art of making components light and slender—and getting away with it. They were also alive to the value of attractive ugliness; a lesson which the Volkswagen pioneers were soon to learn.

But these speculations bring us no nearer to the nature of national characteristics in design. Are we, perhaps, too close to contemporary design? It is certainly not sufficient to say that streamlining is the main feature of recent design. That is literally and metaphorically too superficial. The crude streamlining of the 1920's has developed into a breadth of style that is more natural and organic.

If I may hazard a guess before visiting the Machine Tool Exhibition, it is that good design is international; bad design is painfully national. Good design, I believe, can be ascribed to a date, as a painting can, but only with difficulty can its nationality be deduced. If I am right, then it should be possible to turn the pages of early volumes of ENGINEERING—from the 1860's until, say, the First World War—and learn something of changing styles and fashions during that period. But it would be difficult to extend the study to more recent engineering.

I think we can say, however, that the sophisticated development of streamlining is continuing. Most designs today simplify external appearance. Much more is hidden than is revealed. How odd that this trend is counter to the trend in female dress?

Will the engineers of the 21st Century look back on our designs and view them as we view the fading photographs of our grandfathers and grandmothers?

Letters to the Editor

Helping the British Inventor

SIR, You have recently published a letter from Mr. Kenneth Mason (ENGNG., 10 June, '60, p. 776), commenting on your article entitled "Cold Shoulder for the Inventor (27 May '60, p. 717).

It is quite true that originally Mr. Kenneth Mason approached this Institute on the type of proposition to which he has made reference.

Unfortunately, his correspondence makes no mention of the fact the Institute are not only concerned with the commercialising of members' inventions, but are also much occupied in generally raising the status of the inventor; a matter which escapes his attention in view of his apparent prior interest in commercialising.

In order to carry through our obviously desirable aims and objects, we have to adopt an overall policy and this means that we, ourselves, need to handle the marketing of inventions and the needs of our commercial and industrial board through our central office.

We, in no way, place any curb upon any of our members contacting Mr. Mason, if they wish; a circumstance which apparently has caused some disappointment to your contributor.

Yours faithfully,
R. O. SUTHERLAND,
General Secretary.

Institute of Patentees and Inventors,
207–208 Abbey House,
Victoria Street, London, SW1.
15 June, 1960.

Water Grid on a Single Contour Line

SIR, Some years ago I put forward a number of proposals concerning the construction of a Grand Contour Canal—a continuous canal system located on the 310 ft contour line and joining Britain's main population centres (ENGNG., vol. 176, 1953, p. 741). I believe that in the light of current water shortages, these proposals have assumed a new significance. I must accept the fact that the original scheme, as described seven years ago, has had to bide its time, but such a canal might play a valuable part in the creation of a National Water Grid.

The Sub-Committee on the Growing Demand for Water (Central Advisory Water Committee) have recently published their second report (HMSO 6*d*), in which they state:

> We have received sufficient evidence to convince us that there is now a risk that growing abstractions may seriously deplete the natural flow of many rivers and streams. The chief of these abstractions is for irrigation, which is increasing apace, and which if not regulated could overtax water resources, at any rate in some areas, since little if any of the water abstracted is returned and the heaviest demand tends to occur when flows are at their lowest. . . . While in the short term some control of abstractions is, in our view, unavoidable, we cannot emphasise too strongly that in principle the ultimate object should be a form of control which would also provide for conservation and storage so that water would be available for all legitimate purposes.

The special difficulty which the subcommittee faces is that farmers are rapidly increasing their abstraction of water from streams for spray irrigation. Such water is nearly all transpired by the plants and so lost to the stream, which again in dry weather is sure to be very low, and supply authorities who rely on abstraction lower down might well be placed in grave difficulties.

The subcommittee speak of control of abstraction, but admit the difficulties thereof which surely must be extreme. How would one explain to a farmer that he is limited to an arbitrary 5 per cent of the flow in the stream by his land? The engineering solution is becoming more plainly a Water Grid, either the Grand Contour Canal or in some other form as some readers may prefer to think. Only works of wide geographical range could effect the desired west-to-east delivery of water in sufficient bulk, and distribute it so that all farmers can have as much as they can use, and not specially those who are located by streams. The geographical extent of a grid is also necessary to correlate surface sources with permeable formations suited to storage of water by groundwater recharge.

The situation is becoming serious and it is clear that the solution must be in terms of large-scale engineering.

Yours faithfully,
J. F. POWNALL.

109 King's Road,
Cardiff.
13 June, 1960.

Events in Advance

Electronic Telephone Exchanges

IT WAS not until the conclusion of the Second World War, when experience with predictors and computers had provided sufficient confidence in electronic switching for it to be applied to a public service, that proposals for the construction of electronic telephone exchanges were first seriously put forward.

The use of electronic devices in existing types of telephone exchanges is now common, but the development of the commercially-successful fully-electronic exchange has presented many problems. In this connection, the crystal diode and transistor and the digital store developed for computers have been of great assistance. Experimental exchanges, of two basic types known as space-division and time-division systems, are now planned in several countries.

A conference, which is intended to provide an opportunity for the interchange of information and experiences connected with the construction and operation of fully electronic exchanges of all kinds, both in Britain and overseas, is being organised by the Institution of Electrical Engineers, and will be held at their headquarters, Savoy Place, Victoria Embankment, London, WC2. It will run from Tuesday, 22 November, to Thursday, 24 November next and authors wishing to submit papers for consideration should submit their manuscripts to the secretary of the Institution not later than 15 July.

Further information, and registration forms for those wishing to attend, may be obtained from the secretary of the Institution at the address given above. (Telephone: COVent Garden 1871).

Mining and Metallurgy in the Commonwealth

Southern Africa has been chosen as the meeting place for next year's Commonwealth Mining and Metallurgical Congress. In all, the congress, which will be the seventh of the series, will last for six weeks. The first four weeks, from 10 April to 6 May, 1961, will be spent in the Union of South Africa and the remaining two weeks, until 21 May, 1961, in Northern and Southern Rhodesia.

About a hundred papers are expected to be presented at the various technical sessions which have been arranged and it is hoped that preprints of these papers will be available for delivery to all registered delegates some three months in advance of the congress.

The full and varied programme which has been drawn up will enable delegates to visit not only the important mining and metallurgical undertakings of the three countries concerned but also their attractive coastal areas, as well as game reserves, the Victoria Falls and the Zimbabwe ruins.

A second brochure, giving details of the programmes, including the titles and authors of the papers, information on more than 20 major excursions and an estimate of costs, has now been published. Copies will be sent direct to all prospective delegates who replied to the invitation issued with the preliminary brochure, which was distributed last year to all who are known to be eligible for membership of the congress.

Additional information is obtainable from the congress manager, Seventh Commonwealth Mining and Metallurgical Congress, PO Box 809, Johannesburg, South Africa.

Chemical Effects of Nuclear Transformations

According to an announcement recently issued to the public by the Press service of the International Agency for Atomic Energy (IAAE), Mr. Sterling Cole, the Agency's director-general, has accepted an invitation from the Czechoslovak Government to hold the proposed international symposium on the " Chemical Effects of Nuclear Transformations " in Prague.

The director-general has invited all member States belonging to the Agency, as well as the competent international organisations, to appoint representatives to attend the symposium, which will be held in Prague from 24 to 27 October next.

It is intended that the conference shall deal with the chemical effects of nuclear transformations of organic and inorganic solids, liquids and gases, which are initiated in specific equipment and by the reaction of ions produced artificially by acceleration. The address of the Agency is Kaerntnerring, Vienna 1, Austria, from which further information may be obtained.

Scientific Films go to Prague

Arrangements are now well advanced for holding the 14th congress of the International Scientific Film Association, which will take place in Prague from 16 to 24 September next. As has been the practice at previous congresses of the Association, this year's event will include a Festival of Films Presenting Science.

Films to be shown in Prague are limited to those which have been completed since 1 March, 1959, and which have not been exhibited at a previous congress. They will fall into one or other of the subject categories to be covered on this occasion, namely: the film in research and specialised techniques; films in teaching and training; and films for the popular presentation of science, industry and medicine.

Responsibility for the selection of British films for the congress is in the hands of the Scientific Film Association of Great Britain, 3 Belgrave Square, London, SW1 (Tel. BELgravia 6188), to which all communications from persons and firms in this country should be directed. The congresses organised by the International Scientific Film Association are becoming increasingly recognised at an international level as the leading events in this particular field; this year, for example, upwards of 30 countries are expected to participate by sending either films or delegates and, in the large majority of cases, they will dispatch both.

Meetings and Papers

Institute of Physics

LONDON

Annual General Meeting. 47 Belgrave Square, London, SW1. (Tel. BELgravia 6111). Tues., 5 July, 5 p.m.

Exhibitions and Conference

Chemical Exhibition, International.—Tues., 21 June, to Thurs., 30 June, at Belgrade. Organised by the Exposition de l'Industrie Chimique, Belgrade, Yugoslavia.

Fishing and Allied Industries Exhibition, 20th International.—Sat., 25 June, to Sun., 10 July, at Ancona. Apply to the Ancona Chamber of Commerce, Fiera di Ancona, Ancona.

Recent Research on the Durability of Nickel-Chromium Plating on Zinc-Alloy Die Castings, Symposium.—Afternoon of Wed., 29 June, at the Bontanical Gardens, Edgbaston, Birmingham. Organised by the British Non-Ferrous Metals Research Association in collaboration with the Zinc Development Association. Open to all persons interested in plated die castings, including manufacturers, metal finishers and users. For tickets and further information, apply to British Non-Ferrous Metals Research Association, Euston Street, London, NW1. Tel. EUSton 6411.

Technics and Technical Achievements, Fourth International Fair.—Thurs., 25 Aug., to Fri., 2 Sept., at Belgrade. Apply to Beogradski Sajam, P.O. Box 408, Belgrade, Yugoslavia.

Norwegian Fisheries Fair.—Thurs., 25 Aug., to Sun., 11 Sept., at Bergen. Apply to the secretary general, Norges Varemesse, Tollbudgt 2, P.O. Box 784, Oslo, Norway.

Radio, Television and Electronic Equipment, International Exhibition (FIRATO).—Tues., 30 Aug., to Tues., 6 Sept., at Amsterdam. *Agent:* Mr. W. Friedhoff, 10 Gloucester Place, London, W1. Tel. WELbeck 9971.

Machine Tool Fair, German.—Sun., 11 Sept., to Tues., 20 Sept., at Hanover. Organised by the Verein Deutscher Werkzeugmaschinenfabriken (VDW), 6 Am Hauptbahnhof, Frankfurt on Main.

Radio, Television and Electronics Exhibition, 22nd.—Thurs., 15 Sept., to Mon., 26 Sept., in Paris. Apply to the Syndicat des Constructeurs d'Appareils Radio Recepteurs et Televiseurs, 23 Rue de Lubeck, Paris.

Druggists' Exhibition, International (INDROFA).—Fri., 16 Sept., to Wed., 21 Sept., at Stuttgart. *Agents:* Lep Transport Ltd., Sunlight Wharf, Upper Thames Street, London, EC4. Tel. CENtral 5050.

Public Health Inspectors' Exhibition.—Tues., 20 Sept., to Fri., 23 Sept., at Scarborough. Organised by the Association of Public Health Inspectors, 19 Grosvenor Place, London, SW1. Tel. SLOane 9127.

Preserved Food and Packing Exhibition, 15th International.—Tues., 20 Sept., to Fri., 30 Sept., in Parma, Italy. Apply to the Italian Chamber of Commerce for Great Britain in London, 31 Old Burlington Street, London, W1. Tel. REGent 2411.

Groceries and High-Class Provisions, International Exhibition of (IKOFA).—Fri., 23 Sept., to Sun., 2 Oct., at Munich. Apply to Verein Ausstellungspark e.V., 14 Theresienhoche, Munich 12, Germany.

Technical Exhibition, Tenth International.—Sat., 24 Sept., to Tues., 4 Oct., in Turin. Organised by the Salone Internazionale della Technica, Corso 60 Galileo Ferraris, Turin, Italy.

Food and the Home (Arts Menagers) Exhibition, International.—Sat., 1 Oct., to Sun., 16 Oct., in Brussels. Apply to the Société Cooperative des Industriels et Commercants en Materiel et Produits pour l'Alimentation, 8-10 Place de Brouckere, Brussels, Belgium.

Foodstuffs and Beverages, 12th Trade Fair for (ROKA).—Mon., 3 Oct., to Fri., 7 Oct., in Utrecht. Apply to Stichting Roka, 132 Nieuwe Binnenweg, Rotterdam, Holland.

Machine Tool Exhibition, Italian.—Fri., 7 Oct., to Sun., 16 Oct., at Milan. Organised by the Unione Construttori Italiani Machine Utensili, 22 Via Palestro, Milan, Italy.

Hotel and Catering Industry Exhibition, International.—Thurs., 13 Oct., to Mon., 24 Oct., in Paris. *Agents:* Butler's Advertising Service Ltd., 22 St. Giles High Street, London, WC2. Tel. TEMple Bar 5905.

German Soap Fair, 67th.—Sat., 15 Oct., to Tues., 18 Oct., in Berlin. *Agent:* Mr. Neven du Mont, 123 Pall Mall, London, SW1. Tel. WHItehall 8211.

Effluent and Water Treatment Exhibition and Convention.—Tues., 18 Oct., to Fri., 21 Oct., at the Seymour Hall, London, W1. Organised by the Thunderbird Enterprises Ltd., 140 Cromwell Road, London, SW7. Tel. FREmantle 4063.

Chemical Effects of Nuclear Transformations, Symposium.—Mon., 24 Oct., to Thurs., 27 Oct., in Prague, Czechoslovakia. Organised by the International Atomic Energy Agency, Kaerntnerring, Vienna 1, Austria.

Electrical Techniques in Medicine and Biology, Conference.—Mon., 31 Oct., to Wed., 2 Nov., at the Sheraton-Park Hotel, Washington, DC, USA. Sponsored by the Joint Executive Committee in Medicine and Biology, representing the Institute of Radio Engineers, the American Institute of Electrical Engineers and the Instrument Society of America. Apply to Mr. Lewis Winner, 152 West 42nd Street, New York 36, USA.

Induction Heating Course.—Tues., 1 Nov., and Wed., 2 Nov., at Cambridge. Organised by the Process Heating Division, Pye Ltd. Apply to Mrs. E. Raeburn, Pye Process Heating, 28 James Street, Cambridge. Tel. Cambridge 57590.

Institute of Welding, Autumn Meeting.—Tues., 1 Nov., to Thurs., 3 Nov., in London. Offices of the Institute: 54 Princes Gate, Exhibition Road, London, SW7. Tel. KNIghtsbridge 8556.

Die Casting Exposition and Congress.—Tues., 8 Nov., to Fri., 11 Nov., at the Detroit Artillery Armoury, West 8 Mile Road, Detroit, Mich. Organised by the Society of Die Casting Engineers, 19382 James Couzens Highway, Detroit 35, Mich., USA.

Secondary Surfaces for Heat Transfer with Clean Gases, Symposium on the Use of.—Wed. and Thurs., 9 and 10 Nov., at the Institution of Mechanical Engineers, London. Sponsored by the Institution's Nuclear Energy Panel. Registration required. Apply to the secretary, Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, SW1. Tel. WHItehall 7476.

Institute of Marine Engineers.—*Annual Conversaziones:* Fri., 2 Dec., and Fri., 16 Dec., at Grosvenor House, Park Lane, London, W1. *Annual Dinner:* Fri., 10 Mar., 1961, at Grosvenor House, Park Lane, London, W1.; *Annual General Meeting:* Tues., 25 April, 1961, at 76 Mark Lane, London, EC3. Offices of the Institute, Memorial Building, 76 Mark Lane, London, EC3. Tel. ROYal 8493.

Automotive Engineering, International Congress and Exposition.—Mon., 9 Jan., to Fri., 13 Jan., 1961, at Cobo Hall, Detroit, Mich., USA. Theme: " Ground and Flight Vehicles of Today and Tomorrow." Organised by the Society of Automotive Engineers, 485 Lexington Avenue, New York 17, USA.

Semiconductor Devices, International Convention.—Mon., 20 Feb., to Sat., 25 Feb., 1961, in Paris. Organised under the sponsorship of the Fédération Nationale des Industries Electroniques on the occasion of the 24th exhibition of producers of component parts and accessories. Apply to the secretariat of the Société des Radioélectriciens, 10-14 Avenue Pierre-Larousse, Malakoff (Seine), France.

Rubber and Plastics in Cables, Conference.—Wed., 1 Mar., 1961, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC2. Organised jointly by the Institution of the Rubber Industry, 4 Kensington Palace Gardens, London, W8. (Tel. BAYswater 9101); and the Plastics Institute, 6 Mandeville Place, London, W1. Tel. WELbeck 5439.

Electronic Engineering: Components and Materials Used in, Conference.—Mon., 12 June, to Sat., 17 June, 1961, at the Central Hall, London, SW1. Sponsored by the Electronics and Communications Section and the Measurement and Control Section of the Institution of Electrical Engineers. Apply to the secretary, Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC2. Tel. COVent Garden 1871.

Education and Training in the Plastics Industry, Conference.—Mon. and Tues., 19 and 20 June, 1961, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC2. Organised by the Plastics Institute, 6 Mandeville Place, London, W1. Tel. WELbeck 5439.

Cybernetics, Third International Congress on.—Mon., 11 Sept., to Fri., 15 Sept., 1961, at Namur. Apply to the International Association for Cybernetics, 13 Rue Basse Marcelle, Namur, Belgium.

Engineering in Plastics, Conference.—Mon., 30 Oct., and Wed., 1 Nov., 1961, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC2. Organised by the Plastics Institute, 6 Mandeville Place, London, W1. Tel. WELbeck 5439.

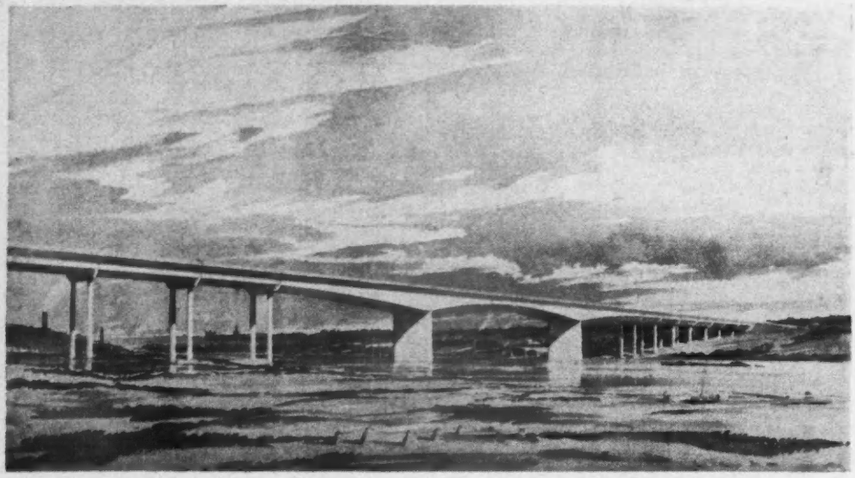
500 ft Span in Prestressed Concrete for Motorway

The new Medway Bridge will have the longest prestressed concrete span in the world—500 ft. Compared with this figure, the next longest in the world is the Conblenze bridge over the Moselle, which has a main span of 403 ft and was completed in 1954. After that comes the Worms bridge over the Rhine, completed in 1953 with a span of 375 ft.

With the approach viaducts and the abutments, the Medway bridge will be nearly two-thirds of a mile long (3,270 ft) with a central span of 500 ft and two adjacent river spans of 312·5 ft to give the bridge a total length of 1,125 ft. The western approach will have eleven spans and the eastern seven, making 21 in all. In addition to the motorway's two carriageways, there will also be separate cycle tracks and footways.

The two main piers of the bridge will consist of hollow reinforced concrete towers built above mass concrete. To make the foundations, excavation within sheet steel cofferdams will have to be taken down to 50 ft below high water mark to reach the chalk bedrock. After the mass foundations have been raised above water level the cellular reinforced concrete piers will provide the springings from which the deck spans will be erected.

The superstructure will consist of independent twin girders, with the side spans cantilevering 200 ft into the main span to support a central 100 ft supported span. Over the piers the girders will have a depth of 35 ft but at the centre of the navigational span the depth reduces to 8 ft. Both the anchor spans and the cantilever spans will be of ceullar construction. The suspended span will consist of two sets of four precast beams weighing 95 tons each. These will support a reinforced concrete deck slab that will be cast *in situ*. The section of the cantilever varies considerably and to investigate conditions under live load, a model was built to about 1/14 scale in prestressed concrete, particularly to determine the stresses in the deep slender webs under combined loading. The model was built and tested at Wexham Springs, the research centre of the Cement and Concrete Association.



The Medway bridge, with a 500 ft main span of prestressed concrete.

To minimise interference with river traffic, the proposed construction method uses little temporary staging; the concrete for the main girders will all be placed as construction proceeds, using travelling formwork which, together with essential plant, will be moved forward on steel or aluminium cages supported by the completed work.

The bridge has been designed by Freeman, Fox and Partners of Victoria Street, London, SW1, acting as consulting engineer to the Ministry of Transport; they will also be responsible for the supervision of the construction. The contract has been awarded to J. L. Keir and Company Limited and Christiani and Nielson Limited, both companies of Westminster, London, SW1. The contract price is £2,325,931, which includes the approaches as well as the main bridge. Work will take about 2½ years.

The award of this contract marks the beginning of the work on the M2, the most important motorway in south-east England. Leaving the A2 on the London side of Strood, the 25 mile long motorway will bypass to the south Rochester, Chatham, Sittingbourne and Faversham. Near Faversham, it will rejoin the existing route to Canterbury, Dover and the Kent coast.

Chemical Grout to Seal and Bind Loose Soils

A chemical that "gels" water and prevents dangerous seepage—a major problem of building, mining and tunnelling—has successfully sealed porous sandstone through which shafts were being sunk in a Scottish coalmine. Quantities of this chemical, developed by the American Cyanamid Company and known as AM-9 Chemical Grout, were injected into the sandstone at depths below 2,000 ft during shaft sinking at the Monkton Hall colliery in Midlothian, one of the deepest shaft sinking operations in British coalmining.

Cementation Company engineers working on the project discovered that conventional grouts, such as cement in combination with silicates, were unsatisfactory in some of the sandstone bands encountered. Nevertheless, seepage continued through the rock and there were difficulties in completing the shaft lining. They turned, finally, to AM-9 Grout which had been successfully used in the United States and found that it would seal the porous sandstone, enabling the shaft sinking to continue.

AM-9 is marketed in the United Kingdom and certain other countries by Cyanamid of Great Britain Limited, Bush House, Aldwych, WC2. It is a dry white powder based on calcium acrylate which, mixed with water, can be applied in an ordinary solution that will penetrate any mass. The water viscosity of AM-9 solution gives it advantages over thicker grouts used in the past. Dissolved in water with a suitable catalyst, it is injected under pressure into the soil or rock formation. The type of catalyst used controls the gelling time which can vary from a few seconds to several hours. The viscosity of the solution remains substantially the same as that of water until just before the gelling starts.

Cyanamid state that the gel not only prevents the passage of water through the porous mass but also binds together soil, sand or loose rock. Stabilised soils below the water table are believed to retain their properties permanently. It is not recommended, however, in cases where it is desired to increase the load-bearing characteristics of soils or rocks.

At the Monkton Hall site the main AM-9 ingredient was mixed at ground level with water and part of the catalyst chemicals and delivered to a holding tank at the bottom of the shaft. The other main chemical necessary for polymerisation, ammonium persulphate, was made up in solution at the bottom of the shaft in batches of 5 gallons which were added to 5 gallon batches of the AM-9 solution to form 10 gallons of fully mixed grout. This grout was injected directly into the ground under pressure by means of a standard Cementation pump.

Treatment of the full depth (approximately 48 ft) of the sandstone bed was carried out from the sump in a series of phases. Three concentric rings of injection holes were provided in the sump. The first injections towards the top of the sandstone bed were made entirely with AM-9 and were carried out primarily to establish the best technique. A total of 3,470 gallons of grout was injected into 16 holes, and subsequent redrilling of injection holes showed that there was a considerably reduced inflow of water.

Prior to the remainder of the AM-9 injection, a preliminary protective curtain was formed with a relatively weak silicate grout to provide a barrier that would prevent undue loss of the AM-9 through open fissures that might exist.

One hundred gallons of AM-9 grout were injected through each of the second series of holes in the section 20 ft to 40 ft below the sump. Gel-time was half an hour and injection rates were from 2 to 4 gallons per minute. Pressures at the end of injection varied from 1,300 to 2,500 lb per sq. in. In the third series of AM-9 holes, the grout volumes injected ranged from nil to 300 gallons per hole and in the fourth series of holes, from nil to 400 gallons per hole.

Before injection the water flow into the sump from the open holes drilled to 60 ft depth was 144 gallons per minute. When the shaft had been sunk through the full depth of the bed of sandstone the water make from the wall was roughly 40 gallons per minute. Of this it is estimated that about two-thirds came from above the sandstone bed or from the upper part of the bed into which the injection standpipes were fixed but which did not receive treatment by the grout.

On the basis of these figures, inflow has been reduced to about one-tenth. It should be appreciated, however, that the volumes of inflow after excavation are from the full bore of the shaft in the porous rock, while the inflow from the drilled holes was from pipes of 2 in diameter.

Density Currents and Silting of Locks

Navigation locks in estuaries frequently separate waters of differing salt content, and therefore of differing densities. This inequality can produce currents of sufficient strength to transport fine bed material into and through the lock. With the lock gates open, the denser estuary water flows in near to the invert while a compensating outflow, of less saline water, takes place in the upper layers.

Such a problem is found in the lock that connects the Queen Elizabeth II dock with the Mersey estuary. The lock is fitted with sliding caisson gates, and the dock level is maintained by admitting relatively silt-free water from the nearby Manchester Ship Canal which is mainly fed by upland rivers. The water in the dock is thus less saline than that in the estuary outside and, at high water, the difference in salinity varies from 5 to 9 parts per thousand by weight. The density currents that arise due to this difference causes silting at rates varying (according to the number of ship movements) between 3,000 and 8,000 cu. yd per week so that frequent dredging is required.

A field study carried out by the Hydraulics Research Station at Wallingford has shown that most of this material is brought into the dock from the estuary by the strong currents generated by the difference in salinity. In one survey, the bottom 10 ft of lock water flowed into the dock at a rate of about 1 ft per sec for 25 minutes while carrying a silt concentration of between 1,000 and 2,500 parts per million.

The problem has also been studied at the Station on a 1/60 scale model which faithfully reproduced the salinity/density current phenomenon. As in the prototype, fresh water and salt water were used in the model. This model formed one of the exhibits at the Conversazione of the Institution of Civil Engineers that was held last week.

The effect of the passage of a tanker through the lock has been studied and possible remedial measures tested. The method that looks most economical as well as effective is the incorporation of an air bubble barrier to break up the silt carrying current. It is not possible to draw off the silty water because there is no nearby site where it could be harmlessly disposed of. An ingenious method for reducing the silt flow was continued in the suggestion of providing " half gates," where only the upper half would be opened when an empty tanker required passage, the whole gate being opened only when necessary.

Aluminium for Electrical Sub-Stations

The advantages of aluminium for structural use were amplified by Mr. J. R. McMullan, design and application engineer of the James R. Kearney Corporation of Canada, Limited, in a paper read before the Engineering Institute of Canada, when they held their 74th annual meeting recently in Winnipeg. Mr. McMullan's remarks were related particularly to the use of the metal in electrical substations.

Tests have shown, he said, that aluminium alloys $\frac{1}{4}$ in to $\frac{1}{16}$ in thick would suffer a loss of only 1 to $1\frac{1}{2}$ per cent in tensile strength, even after exposure to a severe industrial atmosphere for as much as 20 years. In coastal areas the loss would be even smaller. The alloys were practically impervious to sulphur-contaminated industrial atmospheres as well as to salt-laden air, or even combinations of them both. The speaker said that he had also found that they would last well even when adjacent to such alkaline materials as concrete or when in contact with galvanised items such as insulator pins, caps and transmission line hardware.

The light weight of the material was reflected in many ways. The handling of members in the shop required only one man where steel required two men or even a crane. Transportation and structure foundation costs were reduced, and some small structures could even be erected by hand.

Referring to the difference in cost between aluminium and steel, Mr. McMullan said that, though the first cost might favour steel, the savings in transportation and erection made the installed cost in favour of aluminium.

Graduated Lighting for Underpass

A system of graduated artificial daylighting is to be installed in the underpass being completed in London's western suburbs to take the A40 (Western Avenue) beneath the North Circular Road. The graduation in lighting will ease the contrast between day and artificial lighting. Light-reducing canopies above the 220 ft long tunnel approaches will reduce the daylight and the fluorescent lanterns will be more closely spaced as one nears the tunnel portals.

The tunnels themselves, 780 ft long, and the pedestrian subways will also be illuminated by fluorescent lanterns. For the adjacent roads, colour-corrected mercury lighting will be used.

This is the first lighting scheme to be sponsored by the Ministry of Transport for an underpass. The contract for the lighting equipment has been awarded to the General Electric Company and the contractors installing the lighting will be Malcolm and Allan (London) Limited. The consulting engineers for the project are Rendel, Palmer and Tritton of London, SW1.

Foundation Problems in Factory Building

Soil conditions at a prospective site can have considerable effect on the design of a building structure. To provide, for the benefit of managements, an assessment of the factors that might be involved and to explain the need for adequate site investigations, the Building Research Station has produced a new paper in the Factory Building Studies series. It is entitled *Sites and Foundations* and has been written by Mr. A. D. M. Penman of the station's staff; it is published by the Stationery Office, price 3*s*.

Without delving into theoretical soil mechanics, the paper gives a broad picture of most of points to be considered when making the preliminary choice of a site and of the building that can be economically erected there. Potential difficulties due to mining subsidence, swallow holes and clay shrinkage are discussed and so are the problems of frost heave and chemical attack on buried concrete. Possible causes of soil failure and the bearing capacities of soils according to British and some other codes are listed. A brief concluding note sums up existing knowledge on permissible settlements and, in particular, differential settlements.

Building to Resist Nuclear Attack

Gifford H. Albright, assistant professor of architectural engineering at the Pennsylvania State University, believes that the provision of protection against atomic attack does not necessarily mean building cities underground, or the construction of " windowless, ugly, scaleless monstrosities."

Shelter against nuclear weapons can be provided in conventional buildings if shelter requirements are properly understood and if good use is made of " convertible shelter." In every building programme there are requirements for functional spaces which lend themselves to nuclear shelters if designed and constructed with this objective. To acquaint engineers and architects with the requirements of such areas and other fundamental knowledge, the university has instituted an extensive programme of instruction and research.

More knowledge is required about radiation shielding and the response of structures to blast loading, as well as about the psychological and sociological problems that arise when people spend prolonged periods in confined shelters. Some of this information is already available and the first part of the research involves the collating of existing publications.

High Grade Concrete in the Tropics

The increasing demand for high grade concrete in the tropics has to be met despite remoteness from developed areas, difficult site conditions, unskilled labour and lack of technical resources, in addition to the climatic conditions.

The means of overcoming these difficulties were discussed by Mr. K. H. Best, M.I.C.E., in his paper under the above title to the Conference on Civil Engineering Problems Overseas, at the Institution of Civil Engineers last week. He is a partner in Husband and Company, consulting engineers.

By high grade concrete, Mr. Best said that he meant a material having a 28 day strength in excess of 5,000 lb per sq. in and where high standards of workmanship during mixing and placing were required, such as was the case for prestressed concrete. The author outlined in detail measures that might be taken to keep the aggregates as cool as possible, taking all advantage of shade and by painting equipment white to increase radiation. Sprinkling of aggregates with water (to take advantage of cooling by evaporation) was recommended, though care then had to be taken over the total water content of the mix: if ice was used it had to be ensured that all of it had melted before mixing was complete. After placing, the work should be water cured continuously and subsequently should be kept damp or covered by a heat reflecting membrane; alternate damping and drying out should be avoided and the curing water should not be much cooler than the concrete.

Among the points of detailed design for prestressed concrete that Mr. Best recommended were the following:—

The simplest possible arrangement of cables and profile to be used, without complex curvature.

Generous space between ducts, and ample cover, should be provided; beam widths should be wide enough to avoid congestion.

The cover around the end anchorages should be increased above the minimum.

Concrete sections to be detailed to permit simple shuttering, with access for vibrators.

Sharp re-entrant angles should be avoided and, for deep I-sections, generous chamfers should be allowed between web and flanges.

More space for placing was required than was customary in Europe, to permit quicker compaction without loss of quality.

Fire Protection for Steel Structures

A new method of providing fire protection for steel columns and beams has been developed by Cape Building Products Limited of Uxbridge, using their Asbestolux insulation boards.

Either $\frac{3}{4}$ in or 1 in board is used. It is cut to size on site and fixed by wood screws. At joints between the boards, cross fillets are inserted to prevent flame penetration at these points. The screw holes on the asbestos can easily be rubbed down and filled, leaving the surface ready for immediate decoration after priming.

In a test made at the Joint Fire Research Organisation's laboratory at Boreham Wood, casing made up from $\frac{3}{4}$ in Asbestolux protected an 8 in by 6 in steel column from collapse for two hours. The company have evolved a range of specifications to give specific fire protections from $\frac{1}{2}$ to 4 hours duration.

The proposed method of cladding has many advantages, including those of ease and speed of erection as well as low cost. Since hollow ways are left between the webs of the steelwork and the cladding boards, convenient ducting space is available for services; moreover, removable panels can be fitted for access to junction boxes.

British New York Fair Draws the Crowds

Right from the moment the Duke of Edinburgh opened the British New York Show it has been a success. We report the experiences of some of the British exhibitors.

IN HIS message of goodwill to the British Trade Fair in New York, President Eisenhower said that Americans would gain from it greater knowledge and appreciation of Britain today.

From the comment of the American public that has flocked into the Coliseum, the modern exhibition building on Broadway where all four floors are fully utilised by the biggest British foreign trade show yet staged, it is plain that some very quaint ideas about life in the United Kingdom have been given a thoroughly healthy shaking.

The English and American languages are not always the brothers they seem and the woman who thought we were still listening to recorded music on the instrument used on the His Master's Voice label had been misled by the use of the word gramophone. For her it had to be the phonograph in order to be up to date—and for her the superb show put on by the electronics industry has been a revelation.

From the opening, with leading American politicians at the ceremony, the prestige stands, some of the exhibits and some of the British industrial leaders in New York for the exhibition, have all been making an impact on the public through the show itself, through the Press and through television.

EYE WITNESS REPORT

From New York, Sir Victor G. Shepheard, former director of naval construction and Admiralty and now a director of the Dumbarton shipbuilding firm, William Denny and Brothers, and also director of research at the British Shipbuilding Research Association, has sent ENGINEERING his impressions of the exhibition.

Says Sir Victor:

"If the success of the British Exhibition in New York is to be judged by its popularity with the American public, that success is already assured. The attendance on the first three days has been extremely good, and on Sunday, a very wet and unpleasant day, there was almost a capacity crowd during the afternoon. The reception of the Exhibition by the American Press has also been most favourable.

The object of the Exhibition is not only to bring British products before American buyers but also to tell the American public something of the British way of life. And this, the organisers have certainly succeeded in doing, judging by the popularity of the English Inn, the Grocery Shop, Lloyd's Exhibit, Churchill Corner and the lifelike coloured film of a Guards Band marching round Piccadilly.

Every stand in the Exhibition has been crowded with visitors over the weekend and it has been most heartening to overhear so many complimentary remarks about Britain and the work we are doing. A feature of the Exhibition is the way the American public is being told in no uncertain terms, and possibly for the first time, of the great past and present achievements of Britain in science and industry. From the comments one overhears this has greatly surprised our American friends whom, I fear, are far too often ready to believe that all new inventions and developments are of US origin. The policy of the organisers in this respect is certainly increasing the admiration of the visitors for what Britain is achieving and should convince them that we are quite a vital force in world affairs.

The stand of the British Shipbuilding Industry proves very popular with visitors, and it is most stimulating to be asked so many intelligent questions about the exhibits by the man-on-the-street. The British representatives attending the Exhibition have already formed the opinion that the American visitors are of a very inquiring turn of mind.

Finally, the organisers are greatly to be congratulated on this splendid Exhibition. Its main purpose is to increase our exports to the American continent, but whatever the outcome of this, it will certainly succeed in giving the American public a better understanding of Britain and the British."

The Development Councils for the special areas of Britain are at the exhibition in force. They have a good deal to offer the United States, not least being favourable sites for setting up US subsidiaries intending to trade in Europe and the British Commonwealth.

Given a little time we shall be hearing of the success achieved at the fair in the placing of orders, although the majority of its effect must be much more indirect in moulding public and business opinion. The first order did not even wait for the exhibition to be opened.

A Señor Manuel Pando, who is president of Pando Manufactura De Tabacos Imparciales, of Argentina, was in New York and saw the exhibit of Molins Machine Company of London being put up. Señor Pando, three days before the opening, ordered a Molins Mk 8 cigarette making machine, with filter tipping equipment.

Reference was made in our first special article on the fair (3 June, p. 750 and 751) to many of the exhibits and also the fact that many of the lenses used in Hollywood's cameras came from Britain.

Taylor, Taylor and Hobson, of Leicester, a division of Rank Precision Industries, who make the television camera zoom lens used in UK television equipment and in the US are showing such a lens at the exhibition. They are also displaying their Talyrond roundness measuring instrument which has a residual error of not more than a millionth of an inch. The Talyrond is used for measuring ball bearings, gyroscope spindles and other high precision components of the aircraft and automobile industries.

ROPES TO VALVES

The sea conditions experienced off the North East coast of the United States are not more rigorous than those encountered off the East coast of England. Some of the researches carried out by British Ropes Limited at their East coast research department have led to the exhibits now being shown on the stand of their associated company, B R International.

British Ropes have managed to show in New York a little piece of America in London. The company supplies the wire for the prestressed concrete members used in the new American embassy in Grosvenor Square. A small section of beam is on show on their stand. An effective way of catching the American visitors' attention.

The company's stand is also showing samples of the wire rope which suspend the weights down the centre of Big Ben's tower and so provide the power to drive the famous clock.

Tube Investments, not surprisingly, are involved on more or less the grand scale. They have shipped 5½ tons of exhibits and more than a ton of sales literature for what amounts to the principal stand in the engineering section.

From precision tube making, steel production and fabrication, aluminium working, rolling mills and other manufacture and machinery—all the normal and some of the special activities of TI's sixty home and foreign companies are represented.

Placing the emphasis on custom-built precision tubes the stand shows tubes of 39 in bore down to 0·001 in. Since it is just as well to convince a sceptical public that these last really are tubes they are under water and nitrogen is pumped through them, giving off a visible stream of bubbles.

All four floors of New York's most modern exhibition building are being used to house the biggest ever British foreign trade fair.

An ingenious comparison between some New York vital statistics and TI group output has been drawn to get the company's range of operation over to the citizen. New York has 17,800 traffic lights—TI sell more than 55,000 traffic signs each year. Madison Square Gardens, no distance off, seats 20,000—TI make enough tubular chairs in a month to replace the lot.

And again: the Statue of Liberty weighs 225 tons and Tube Investments produces more than that much steel every two hours throughout the year.

Only four months ago British diesel Leyland trucks of the type on show in the Coliseum motor show broke into the US home market. Now orders are flowing into the Lancashire commercial vehicle group.

The British diesel engined truck offers American "truckers" unusual economy in operation. Yale Express Systems, of New York City, have told Leyland that they are operating one of the Chieftain trucks carrying loads between 10,000 and 12,000 lb over fast American highways in New Jersey with a regular fuel consumption of 18 miles from a US gallon, 21·6 miles to the Imperial gallon.

A high performance teleprinter, whose makers claim it to be the smallest and lightest now commercially available, is being shown in the official British Government exhibit on the ground floor. It is the Creed model 75, produced by the Croydon, Surrey, firm of the same name. Space in the Government exhibit was not bought by manufacturers. The products shown there were selected on special merit.

Orders for the Creed 75, capable of transmitting up to 100 words a minute, have already come in from the United States and 32 other countries. A radio version of the machine, made by the Creed company, was the first to be used on an airliner on scheduled passenger flight, because of its reliability in non-level positions.

J. Blakeborough & Sons, the valve specialists of Brighouse, Yorkshire, are showing a range of their fluid control valves for nuclear and conventional power stations. One of these is the reactor charge-discharge valves as supplied to the Bradwell nuclear power station. An oil tanker gate valve, a power check forced closing, non-return valve and a pressure reducing valve for water service are among the Blakeborough exhibits.

Human Element

Management Courses at Delft

THE Research Institute for Management Science, at Delft, (Research-Instituut Voor Bedrijfswetenschappen) is to conduct three highly promising seminars and training courses later this year.

A variety of foreign companies are expected to send staff and the courses will be conducted in English.

From 3 to 31 August the Institute's seminar on simulation techniques and their application to industrial management problems will be in session at Delft. Its leader is to be Professor Martin Greenberger of the School of Industrial Management, Massachusetts Institute of Technology. Between the introductory week and the final evaluation seminar of two days, there will be two and a half weeks of practical field studies.

A four day international seminar on requirements and training of scientific and technical personnel will be held from 11 to 14 October. This is intended for departmental and general managers and for personnel and training officers.

The longest course is from 3 October to 23 December, on the setting up and expansion of industries. This course has four main headings: preliminary survey; detailed planning; building, installing and starting up; organisational problems.

Complex Claims to be Made to Ford Motors

Few of the major car companies are long without trouble in one shape or another. Last week it was production cuts for Vauxhall and a BMC works.

Next week, on 27 June, the representatives of the 22 unions who belong to the Ford company's national joint negotiating body are to hold a meeting from which will emerge a subsequent request to meet the management with a formidable series of claims.

Some of the local Dagenham opinion supports an hourly claim that would put around £3 a week in most men's pay packets. This is only useful as a guide to the rank and file pressure behind the official union negotiators.

Dissatisfaction was expressed when the working week in Ford plants was reduced from 42½ to 41¼ hours. There is now strong feeling for a demand that it should be cut to 40 hours for day shifts and 37 at night.

Three weeks holiday with pay will probably also appear on the list. It is becoming an increasingly frequent demand among other industries, including coal mining. Differentials, naturally a thorny subject, can hardly be avoided. Both the Electrical Trades Union and Amalgamated Engineering Union members want small but significant alterations in certain grades or departments.

When demand is as heavy as it is for Ford cars, especially the smaller models, some odd things must happen. This is reflected in the likelihood of a claim for overtime pay for work done in the dinner break.

Outside strict union agreements, Fords have always maintained complete freedom for management decision. One effect has been the operation entirely at the management's discretion of the merit scheme which rewards skill, work standards and conduct. Modifications designed to enlarge the recognition given to particular skills will at least be proposed and more sweeping changes have been advocated locally.

Supervising the National Coal Board

The uproar following the *Guardian's* revelation that Mr. Alfred Robens, the Labour Party shadow cabinet member for labour relations, is to become chairman of the National Coal Board, shows how far the United Kingdom is from practising the kind of parliamentary democracy customary in the United States.

There important sectors of the national administration and the economy come under the scrutiny of Senate committees on which Republicans and Democrats serve together. Their examination of, and influence upon, public affairs is something to which the Westminster pattern of *ad hoc* committees upon Bills as they come up is not to be compared.

If such a committee for fuel (or energy) existed in London then two things are certain. Spokesmen of the National Union of Mineworkers would be on it, through the Parliamentary Labour Party, and the union might have thought of a contribution more constructive than its hope to have coal protected against other, more flexible, fuels.

It is also virtually certain that Mr. Alfred Robens would have been a leading light on such a joint body. It would not have been a situation in which confused voices could have muddied the waters and hidden the real issue.

What the Coal Board wants is a leader who will secure for coal the maximum possible welcome in industry and the home. This is a matter of producing the right coal at the right place at the right price: a Miles Thomas, Leonard Lord, Ivan Stedeford or a Nelson of Stafford have the background of industry and of successfully driving great organisations the way they want them to go.

Mr. Robens has not. And his experience with Atomic Power Constructions at the Trawsfynydd nuclear power station was as labour relations adviser. No doubt Mr. Robens has a unique contribution to make to the coal industry. It might have been better made as vice-chairman with special labour responsibilities under a chairman of proven industrial achievement.

Who Wants to Go to Australia

Mr. G. F. Anderson, the managing director of the Australian company S.A. Tool and Gauge, who as this page reported last week has conducted a five week tour of British firms, had a disappointing experience.

In all his intensive inquiry among United Kingdom companies he did not succeed in finding one that was actively seeking to open up operations in Australia. Although his visit took place only a few weeks ahead of the Hoover announcement of lower demand and of dismissals, Mr. Anderson told ENGINEERING that so far as he could see the home market was so greatly absorbing the capacity of United Kingdom companies that none were seriously interested in Australian expansion.

Mr. Anderson's efforts to find manufacturers keen to have their products manufactured under licence by Australian plants were equally unrewarded. "It's a very luscious market you have at home here," he said, "and that seems to determine people's attitude."

It is fair to record that Mr. Anderson is under no illusions about the difficulties involved in starting up in Australia.

Dispersed Markets

He likened it to going after a market "no bigger" than London but with its people spread out over the length and breadth of Europe. Transport costs, of components and of finished products, are a major factor to be reckoned with.

In time the Pacific area is bound to become a substantial market for manufactured goods and Australia, along with Japan and the Western States of the USA, will be best placed to do the supplying. This is acceptable reasoning to the major companies who can set up subsidiaries in the knowledge that they may take ten years to become fully profitable.

It is not the same proposition for the smaller company that must break even in the first year or two.

The areas of the economy in which Mr. Anderson saw the greatest prospects for important further growth in Australia were plastics, electronics, aluminium and—in finer focus—in the application of air conditioning.

He left behind the germ of an idea that the hovercraft developers might well apply themselves to. Each year from the Australian hinterland large herds of cattle are towed in cattle-trains to the coastal towns and the meat plants. The long hot journey is one in which proper watering is an enormous problem and the animals still arrive with much of their condition lost. This is not good for the beasts and not good either for the farmers' pockets.

In place of the relatively slow moving cattle-trains, Mr. Anderson would like to see hovercraft speeding over the vast flat spaces, cutting the journey time, the costs and the losses. In fact, he was told that he had better bring the idea back again in a few years time.

A Changing Tune for North Wales

With its slate industry long in decline and its young people emigrating without serious difficulty to the prosperous Midlands and London, North Wales has for some time been picturesque only to the surface view.

Along the valleys the small grey houses have housed unemployment on a scale worse even than the Scottish lowlands or Northern Ireland.

But the area has an asset, even if it is 100 miles from the factories of Lancashire and the West Midlands. Its labour is adaptable—and all too available. The problem has been as bad in Caernarvonshire as anywhere, with an unemployment percentage of 6·5, against the national average of less than two.

It is in Caernarvonshire, the Nantlle valley, that the Austin Hopkinson company has now opened a new factory for making mining equipment. One factory does not make an affluent society: Austin Hopkinson will employ 180 people at first and there are a thousand and without work in the district. But where one company has led others may well follow.

Possibly the vigorous representations of what Wales can do that are currently part of the British Trade Fair in New York may lead to some United States investment in North Wales.

The new factory in the Nantlle valley was opened by Lord Brecon, Minister of State for Wales. He went on the next day to open an extension factory built for the Elephant Chemical company at Barmouth, the estuary town in Merioneth.

Pay Rises for Government Scientists

Pay increases of between £50 and £290 a year for scientists in the Civil Service have been agreed between the Treasury and the Institution of Professional Civil Servants.

For the 9,000 scientists the awards are backdated to October, 1958. About 280 Ordnance Survey workers, the lithographers, photographers and printers responsible for reproducing the ordnance maps, receive an arbitration award of between £25 and £75 a year backdated to September, 1957.

The Government scientists are in the interesting position that some time after the end of the year their salaries will again be altered. But they cannot yet tell whether the move will be up or down. This will depend upon the report of the Civil Service Pay Research Unit, which exists to make comprehensive comparisons with outside employment.

The increases just announced follow the improvements recently made in the pay of executive and administrative classes of the Civil Service.

Employed Rise by 77,000 in April

The total number in civil employment in April, rose by 77,000 to 23,420,000. A Ministry of Labour announcement indicates that the largest labour gains were made in the engineering industries.

The employment figure at the end of this April was better than that of a year ago by almost 400,000.

The black spots are coal mining and shipbuilding where there have been some reductions in the numbers at work.

The Ministry's analysis of the unemployment position in mid-May shows that of the total of 341,176 some 59 per cent had been out of work for more than eight weeks. The biggest reductions in the numbers of unemployed had been in manufacturing industries—9,576, miscellaneous services—6,960, in construction—6,603 and in distribution—4,748.

More than 50,000 of the total are married women.

International Machine Tool Exhibition, London 25 June—8 July

Apart from the actual machines on show at the Machine Tool Exhibition there are several displays of tools and machine components. Ceramic tools have made considerable progress in the last four years, as has the type of tool that uses disposable tips. On this and the next three pages is the second instalment of descriptions of items on show.

POSITIONING CONTROL

THE Emicon 400 is a low price positioning system for machine tools.

Information is supplied by tape to give a nominal accuracy of 1 part in 400,000. A specially designed positioning table is not required. Speeds up to 300 in per minute can be controlled by the system, which measures the rotation of a lead screw or pinion and so can be adapted to many existing machines. Heavy work-pieces can be moved as the machines themselves supply the power.

The datum point can be located anywhere in the travel of the workpiece, and a more comprehensive range of instructions than usual can be programmed on the tape. *EMI Electronics Limited, Hayes, Middlesex.*

TANGENTIAL SCREWING MACHINE

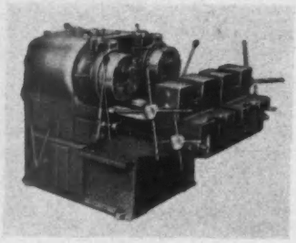
Twin Head

A REDESIGNED version of a twin head tangential screwing machine has now been put on the market.

The machine is arranged for driving from a constant speed electric motor of 7½ h.p. running at 1,420 r.p.m. It is fitted with tangential die heads that can either have the dies opening automatically when a predetermined length of thread has been cut, or can be opened at any point by release levers on the side of the machine. Automatic closure on the return of the carriage is also fitted.

The drive is taken from the motor to the gearbox through V-ropes. The headstock has a four speed sliding gear for speed change and the drive from this is taken to a separate two speed headstock in the main casting of the machine, also by V-ropes. This arrangement allows for eight spindle speeds covering the range from 15 to 190 r.p.m. in the standard version.

The gearbox is splash lubricated and all driving shafts are mounted in ball and roller bearings. The main spindles are



mounted on parallel and angular contact roller bearings. A reversing mechanism can be fitted to the right hand spindle so that left hand threads can be cut on it at the same time as right hand threads are being cut on the left hand spindle.

The travel of the carriage is 15 in and a lead screw to the saddle can be built into the machine if desired. The capacity for screwing bolts is from ¼ in to 2 in diameter and for pipes from ¼ in to 2½ in diameter. The machine occupies a floor space of 7 ft 9 in by 5 ft 4 in and weighs 52 cwt, net. *Joshua Heap and Company Limited, Oldham Road Engineers' Tool Works, Ashton-under-Lyne, Lancashire.*

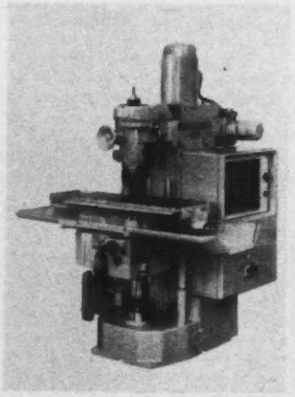
PROGRAMME MILL

Three Dimensional Working

NOW available in this country is the Loewe FS4Pr programme milling machine which will operate in three dimensions.

The work table has a chucking surface of 11 in by 31½ in with a longitudinal power movement of 20 in. Vertical power movement is 4 in and hand adjustment 12 in. The spindle has six speeds from 710 to 2,240 r.p.m. as standard, but the range can be extended to 180 r.p.m. if desired. The ram has a power cross movement of 10½ in. Longitudinal feed rates range from $\frac{1}{16}$ in per minute to 25 in per minute in 20 steps, and the cross feeds from 3½ in per minute to 25 in per minute in 10 steps. Rapid traverse is also included.

The preselected programme is set up on the keyboard and the actions follow in sequence, although more than one operation can be carried out at the same time. Movements are stopped by adjustable trip dogs initially positioned by trial runs under hand control. Plug-in masters and exchangeable holders for



dog combinations facilitate setting up for different workpieces in batch production. All three movements can be set and used so that a workpiece can be completely machined at a single setting. Once set-up the operation is fully automatic. *George H. Alexander Machinery Limited, 82-84 Coleshill Street, Birmingham 4.*

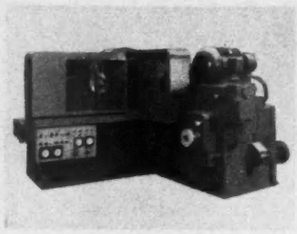
GRINDER

For Brake Discs

A SPECIAL purpose machine, the No. 632 grinder, will take discs for brakes between 9 and 14 in diameter.

The disc is held on a rotating spindle and the faces are ground between two peripheral wheels. Twin work spindles housed in a large diameter drum allow one disc to be loaded while another is being ground. The grinding wheels retract just sufficiently to allow a disc to pass between them, and feed in hydraulically to stops. Size and finish are maintained by diamond dressers which automatically traverse the wheels at preset intervals, and the drum carrying the work spindles oscillates as the disc is being ground. The work spindles are floating to allow the disc to assume a central position before being clamped hydraulically.

The wheel spindles are driven by 15 h.p. motors. A new wheel is 24 in diameter and can be worn down to 18 in before renewal is required. Interchangeable spindle pulleys are provided to compensate for change of speed due



to wear. The drive to each work spindle is by worm and wheel and the spindles are housed in a drum which rotates through 180° to move them between loading and grinding positions. The whole drum is mounted on screw adjusted slides to allow for different disc sizes.

The infeed of the grinding heads is infinitely variable between 0·004 and 0·03 in per minute. The rate at which the dressers traverse the wheels is variable between 2 and 30 in per minute, and the depth of dressing cut from 0·0002 to 0·002 in in ten steps. *Lumsden Machine Company Limited, Hawks Road, Gateshead 8.*

UNIVERSAL PRESS

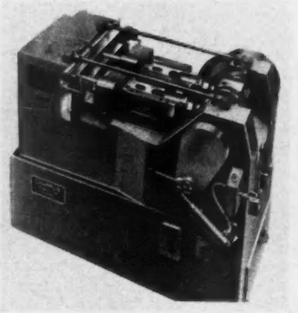
Strip Stamping

THE Chappuis press type PAU, now available in this country, is designed for the high speed production of small and medium stampings from strip.

The machine has twin dies that can be operated simultaneously or separately each being capable of exerting 20 tons. Wear on the machine is reduced if independent working is used. The frame is stress relieved cast iron and the crankshafts are nickel chromium steel. Slides and cradle are easily adjusted for wear, and oblong holes are provided in the top surface of the slide for punch block removal tools.

Strip feed is by rollers which grip the material on the faces and not on the edge. Standard capacities are for strip up to 3·15 in wide. Thicknesses can be between 0·004 in and 0·118 in. The clamping mechanism is adjustable to suit the material being used and can be engaged or released instantaneously.

Accuracy is obtained by an auto stop lever fitted to each tool allowing a safety margin without additional material width. An electropneumatic safety device can also be fitted, if desired. This brakes the machine if the strip is not positioned correctly or the end of the coil is reached. The ejection levers are actuated by a cam on the crankshaft which can be set for any point in the cycle. They can also be used to control auxiliary movements. Drive is by a one or two speed motor through three speed pulleys. *Stuart Davis Limited, Much Park Street, Coventry.*



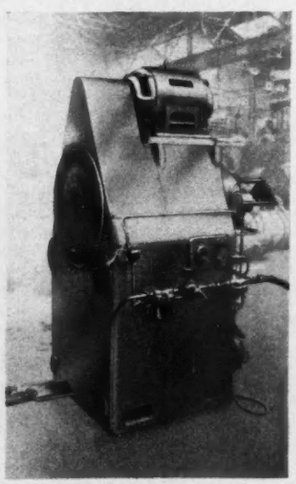
SWAGING MACHINE

Rotary Spindle and Head

A NEW rotary swaging machine, the 20SI, has a slowly rotating spindle and rapidly rotating head.

The machine has a capacity for tube up to 2 in diameter or bars up to 1 in diameter, but dependent on the material and amount of reduction required. The main motor is rated at 10 h.p. and the spindle motor at 2 h.p. The main driving head speed is 200 r.p.m. while the spindle revolves at 20 r.p.m. The drive to the spindle is through an endless toothed belt and worm reduction unit. Around the spindle is rotated the main driving head which houses the hardened steel striking rollers carried in an aluminium bronze cage. The rollers make contact with both the inside of a hardened alloy ring shrunk into the main flywheel pulley, and the outer diameter of the spindle head.

The flywheel pulley is mounted on taper roller bearings and is also driven by an endless belt. Hammer blow and die wear take up are by means of renewable hardened shims. The addition of a



rotating spindle automatically obviates finning. *Sir James Farmer Norton and Company Limited, Adelphi Iron Works, Salford 3, Manchester.*

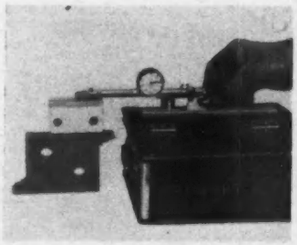
ROUGHNESS TESTER

Mechanical Operation

A NEW roughness comparator bases its performance on the measurement of the friction coefficient of machined surfaces and can be calibrated to most standards.

The measuring unit consists of a sensing head in the form of a pivoted wheel of special alloy connected to a dial indicator and retained in the zero position by a spring. To assess the finish on any particular surface the sensing wheel is moved repeatedly to and fro across the surface. The friction between the surface and the sensing wheel will cause the wheel to rotate, moving the pointer over the scale and tensioning the spring until such time as spring tension balances the friction drag and the wheel ceases to rotate.

The indicator reading is retained by a ratchet and pawl and the surface roughness can be read directly from the dial which can be calibrated in terms of either centre line average (CLA) or maximal depth. Before taking another reading the pawl must be released which



will allow the pointer to be reset to zero.

Claims for the instrument are its low cost; absence of power supplies; ability to be used anywhere; robustness sufficient for use in the open shop; non-magnetic construction so that it can be used on components that are still clamped on a magnetic chuck; its small size and speed of operation.

Not only can surface finish be assessed, but also scratches and flaws can be detected. All types of components can be tested, including internal bores. Extension pieces are available to increase the reach. *Rubert and Company Limited, Acru Works, Demmings Road, Councillor Lane, Cheadle, Cheshire.*

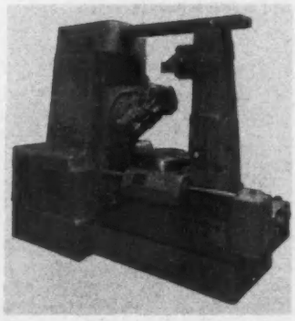
GEAR HOBBER

Diffraction Grating Control

THE model PH30 gear hobber which will cut gears up to 30 in diameter has been made to incorporate the NEL diffraction grating system for table control.

The system is fully automatic. A circular diffraction grating with 21,600 radial lines is mounted inside the table and another with 180 lines on the worm drive shaft. The ratio of the line numbers is the same as that of the gears. Therefore the lines pass given stationary points at the same frequency. Any errors in the transmission of the table drive will cause the lines in one grating to be ahead or behind those in the other. By having a light source on one side of each grating and a photo-cell on the other, sinusoidal signals are generated from each unit when the machine is running. By comparing the phases of these signals any errors in table transmission are measured.

An amplified error signal is fed back through a servo correcting mechanism to impose a fine correction on the



transmission, and hence the accuracy of the machine will never vary due to wear. All the electrical equipment is housed in a small console measuring 4 ft by 2 ft by 2 ft, which can be remote from the machine. It is quite independent of the operator. The measuring system has an accuracy of ± 1 second of arc, which corresponds to a distance of 0·00015 in on the periphery of a 30 in diameter gearwheel. *David Brown Machine Tool Division, Sherborne Street, Manchester 3.*

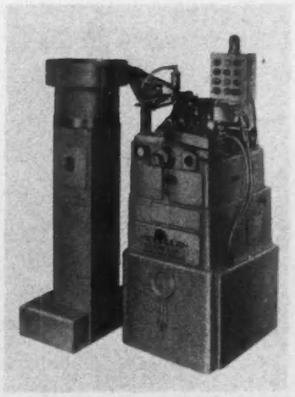
GEAR SHAVER

for Fine Pitches

DEMONSTRATED with a hopper feed and fully automatic cycle, the VS4A is a gear shaving machine for fine pitch work.

The machine has a capacity for spur or helical gears from ¼ in to 4 in diameter and face width of 1 in. Minimum pitch is 180 d.p. and the maximum 16 d.p. The component shaft length can be 6 in and the shaving tool diameter is from 2 to 4 in.

The machine will be set up at the Exhibition to cut 51 tooth 1 module helical gears of 0·275 in face width at a rate of 120 per hour. The precut blanks are fed from the hopper to a slide placed above the workhead and tailstock; in the slide the gears are held by a gate mechanism that delivers them singly into position for shaving. With the gear located on an arbor the pneumatically operated tailstock clamps the blank and the shaving cycle commences. On completion the gear is stripped from the arbor and passes out down the delivery chute.



Full electrical and pneumatic interlocking is incorporated in the circuit design and the machine is safeguarded against faulty or uncut blanks. A range of four tool speeds is provided and the stroke is variable as required. *W. E. Sykes Limited, Manor Works, Staines, Middlesex.*

PROFILING LATHE

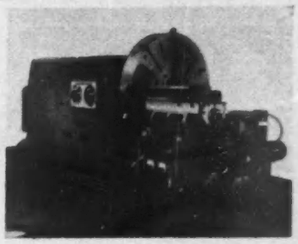
Copy Turning

THE Ravensburg model KH45 is one of a range of lathes designed for machining deep and difficult profiles which are not suitable for hydraulic single coordinate copying methods of operation.

The method employed is the Unicop electrohydraulic two-dimensional system which is capable of reproducing practically any shape, the limitation lying only in the tools. Normal turning operations can be carried out without the use of tracer and template, and the changeover from copying to normal turning is made by depressing a single button on the control panel.

For normal turning the hydraulic system of the machine provides transverse and longitudinal feeds in both directions together with rapid travel. Feed movements are completely independent of each other and are infinitely variable. Constant cutting speeds are obtained by linking the feed to the spindle speed.

Infinitely variable spindle speeds from



1·6 to 560 r.p.m. are provided by a Ward Leonard drive working in conjunction with a 12-step gearbox. Feed rates are variable between 0·04 and 0·7 in per minute.

The turning diameter over the bed is 43·3 in and the faceplate diameter is from 31½ to 39 in. The machine is robustly constructed to accommodate large workpieces. Unsupported workpieces up to 16 cwt and having a centre of gravity at 12 in from the faceplate can be machined continuously. The maximum torque available at the faceplate is approximately 360 lb-ft. *Sykes Machine Tool Company Limited, The Hythe, Staines, Middlesex.*

RADIAL DRILL

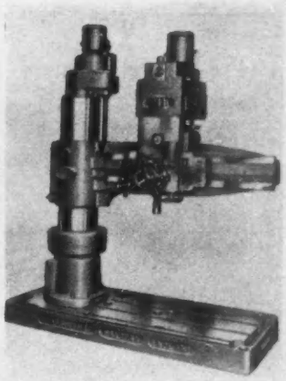
6 ft Radius

A NEW addition to the range of radial drills is the Asquith 3PS machine which has a working radius of 6 ft.

The drill is of the pillar and sleeve design with a 2½ in spindle for heavy duty. A vertical motor drives the spindle through a flexible coupling and spur gearing. The standard machine has 12 speed changes in a choice of five ranges, each range giving an overall ratio of 26·8 to 1.

A six feed gearbox is fitted as standard, giving feeds from 0·006 to 0·04 in per revolution. A single lever and index plate provides the selection. A trip dial graduated in $\frac{1}{32}$ in can be set to disengage the feed at any point so that repetition depth drilling can be obtained. Fine hand feed for the spindle is available in addition to the power feeds. Reverse to the spindle is obtained by reversing the motor.

A single lever on the slide controls start, stop and reverse of the spindle and also the elevating and lowering of the arm. This lever is also used for inching.



Slide traverse is actuated by the handwheel on the front of the slide. Locking of the slide to the arm is mechanical by a hand lever but locking of the sleeve to the pillar is by an electrohydraulic system controlled by a selector on the slide. *Drummond-Asquith Limited, King Edward House, New Street, Birmingham 2.*

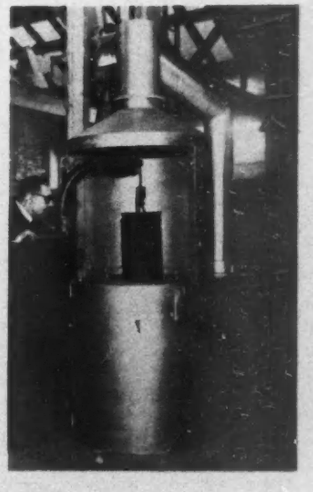
LIQUID BATH FURNACE

Air Blast Heated

AIR blast heating is used for a liquid bath furnace suitable for fusible salts, cyanide, or lead.

Normal maximum operating temperatures are 900° C with a calorised mild steel pot or 1,000° C when a heat resisting steel pot is fitted. The furnace casing is in steel plate and the top plate is cast iron. A typical example measures 9 in diameter and 13 in deep in the pot, and has a salt capacity of ¼ cwt.

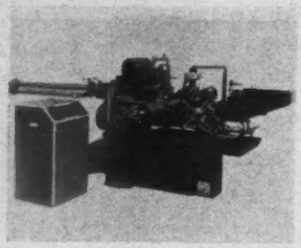
Heating is effect by a single nozzle burner of the diffusion type which is applied tangentially towards the top to ensure that melting occurs first at the top. The products of combustion are drawn off at the bottom. The burner is designed to run on town's gas, and a governor is incorporated to keep the feed pressure constant. A gas and air proportioning valve maintains the ratio of gas and air constant throughout the range of the burner to ensure maximum efficiency combined with correct firing. Operation is by a single lever. The furnace is available as an open type or



with various hoods. The jib crane can also be used as a depth control. *Brayshaw Furnaces Limited, Belle Vue Works, Manchester 12.*

CAPSTAN LATHE

Punched Card Control



THE standard 2D capstan lathe for repetition bar work up to 1¼ in diameter has been fitted for punched card control.

The Auto-Robot system gives automatic control of every movement of the machine, including the Autobar chuck. Setting the control system is done by placing a punched card over a printed circuit, the holes in the card having been positioned to correspond with the signalling switch circuits required for a complete work cycle. The signalling circuits are then energised by means of a scanner and, in their turn, actuate air cylinders connected to the machine elements that are normally hand operated in the standard machines.

It is claimed that the equipment reduces idle time and eliminates abnormal tool wear by virtue of the fact that optimum speeds and feeds are automatically selected, rates of feed are constant and overlapping of slide and tool movements can be precisely set and mechanically actuated.

The automatic equipment can be fitted to existing 2D lathes of the plain saddle type and is suitable for repetition work where small batch sizes do not warrant the introduction of multispindle automatic machines. No major modifications are required and it is hoped to extend the application to other types of 2D lathes in the future.

The control panel is duplicated by a set of hand switches for setting up purposes, and hand pilot-wheel control to the capstan is retained. The Autobar chuck with the weight operated bar feed unit ensures accurate length feeding automatically. *Alfred Herbert Limited, PO Box 30, Edgwick Works, Coventry.*

DISC GRINDER

1 in Thick Abrasive

THE use of inserted nuts has enabled grinding discs with 1 in of usable abrasive to be incorporated in two horizontal disc machines.

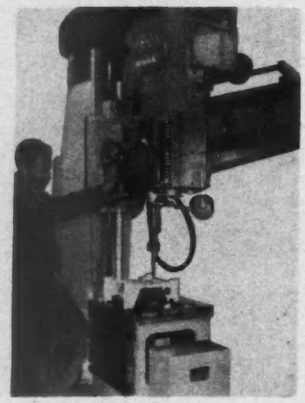
The model 28 illustrated is the larger with a diameter of 53 in and a disc speed of 480 r.p.m. The size enables components from 20 in by 10 in down to 2 in by 2 in (about the smallest practicable size) to be surfaced. Power is supplied by a 12½ h.p. motor running at 1,450 r.p.m. and the disc height above the floor is 32½ in.

Features claimed are extreme rigidity and compact design. There is a built-in dressing device. The disc runs on a roller bearing spindle and can easily be changed; discs are available in the full range of gradings. The spindle unit is built for smooth running with a large flange to support and drive the disc. The bearings are sealed from the entry of grit or dirt. The drive is by multiple V-belts from a totally enclosed motor which has provision for belt adjustment. Lubrication is by grease nipples.

The disc normally fitted is in six sections with screw fitting. The thickness of 1 in allows long working periods without maintenance or replacement. Dust collection ducting and a vane guard ring are incorporated, and the 10 in outlet can be connected direct to the works extraction system. Alternatively, a collector unit is available making the grinder completely self-contained. The model 26 has two variants with discs of 30 in and 36 in diameter running at 850 and 720 r.p.m. respectively. Otherwise the construction is generally similar. *Jackman Machine Tool Company Limited, 73 Eastbournia Avenue, Edmonton, London, N9.*

RADIAL DRILL

Programme Control



AN UNUSUAL feature of the MAS VR4A radial drill is the fitting of programme control.

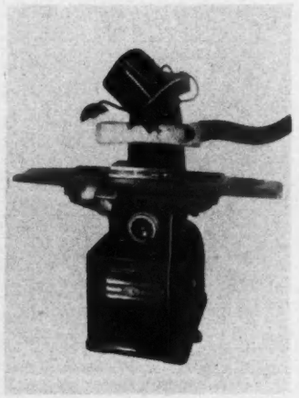
The machine has capacity for drilling up to 2 in diameter in steel and will bore up to 7½ in diameter. Maximum reach for drilling is 9 ft 7½ in and minimum pitch circle is 3 ft 7½ in. The arm has a vertical movement of 29½ in and the spindle travel is 12½ in. Sixteen spindle speeds cover the range from 28 to 2,500 p.m. and 16 feeds from 0·002 in to 0·08 in per revolution. Power elevation is by a separate motor.

Hand selection of feeds and speeds can be made by push button during the preceding operation, engagement occurring when the hand lever is depressed. For multiple production, speeds and feeds as well as depth limits can be set on the programme controller for as many as 20 consecutive operations, the initial settings being made during the first run. The operation of the machine is then limited to the changing of tools, the setting of the required position of the spindle and motor starting and stopping.

Operation is also simplified by the centralisation of several movement controls. A single hand lever controls the engagement of hand and power feeds and spindle speeds. *Elgar Machine Tool Company Limited, 172–178 Victoria Road, Acton, London, W3.*

SHARPENER

for Segmental Surface Broaches



THE machine illustrated has been specifically designed for sharpening surface broaching tools of the segmental type.

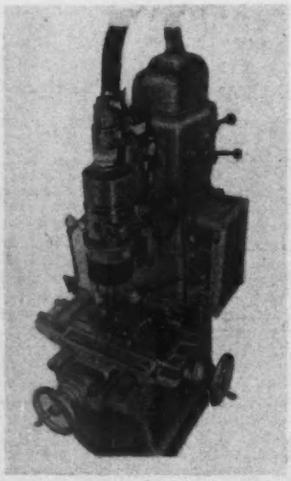
It is a power-driven machine and was developed from an earlier hand operated one. The spindle head assembly has been made free to swivel on the sliding head and the latter is mounted to float freely in Ina needle roller bearings. Alternative methods of operation are by grab handle or by a side-mounted lever according to the customer's choice and requirements.

The cross traverse has a movement of 9 in and the table traverse is 24 in. The table traverse is operated by a worm and wheel feeding a rack and pinion giving a a coarse feed of 0·3 in per revolution of the hand wheel or a fine feed of 0·015 in per revolution through an additional 20 to 1 reduction.

The wheel spindle is suitable for speeds of up to 11,000 r.p.m. and will take wheels up to 6 in diameter. The bearings in which the spindle runs are a precision matched pair, angular contact type at the driven end, and single row ball at the driving end. The drive to the spindle is taken by a flat belt from a ¾ h.p. electric motor running from standard mains supplies. *Abwood Machine Tools Limited, Princes Road, Dartford, Kent.*

JIG GRINDER

Holes and Contours



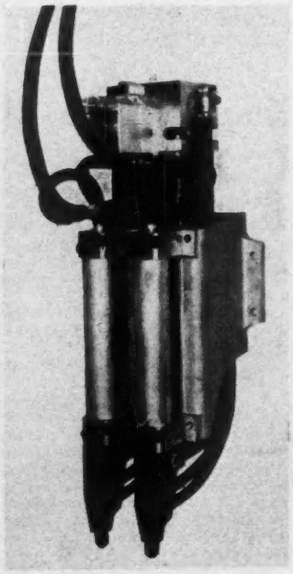
SEVERAL new features are incorporated in the Moore Model 2 jig grinder.

A particular claim is for a high rate of metal removal, which is said to be due to the use of an air driven grinding head developing 1 h.p. at 40,000 r.p.m. This is sufficient to open out a 1 in diameter hole by ½ in in a single plunge cut at a rate of 1 in thickness in 5 minutes. The full range of speeds is from 12,000 to 80,000 r.p.m. with stepless variation. The machine has a capacity for workpieces up to 10 in by 16 in by 16in high.

A new attachment is for grinding slots and is driven by a ½ h.p. motor. Used in conjunction with a form dressing attachment for shaping the wheel, form grinding of the work piece is made possible. A feature of the new machine is the provision of a hand wheel by means of which contour grinding can be carried out using adjustable angular stops on the planetary motion of the main spindle. Accurate angular graduations are marked for indexing slot grinding. These are accurate to within 0·0002 in on an 8 in diameter. *Catmur Machine Tool Corporation Limited, 103 Lancaster Road, Ladbroke Grove, London, W11.*

WELDING UNITS

Air Operated



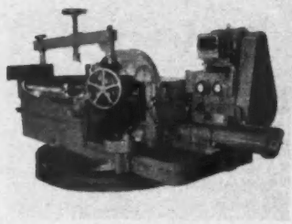
THE welding unit shown in the illustration is the DP60, a weld/press set for mild steel sheet of up to 20 gauge.

The unit comprises a tapped welding transformer complete with four stage air cylinders having electrically operated valves and secondary jumpers.

The operation is on the series welding principle and the pitch adjustment provided on each unit is from 1 in to 4½ in. It is possible to control one or several of these units from one of the firm's control panels with the units arranged for operation in cascade or simultaneously. There is a choice of condenser charging timing and ignitron contactor methods or, alternatively, the units can be completely electronically controlled. The output of the transformer is 10,000A when two 20 gauge sheets are being welded, and a built-in pressure switch ensures that the current cannot be initiated until full pressure has been built up. *ARO Machinery Company Limited, 190 Castelnau, London, SW13.*

COLD SAWING MACHINE

Table Type



THE table type cold saw illustrated has a 42 in diameter blade.

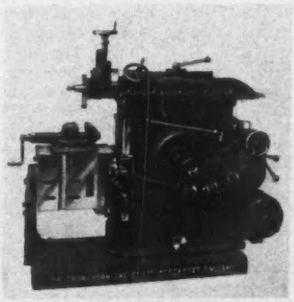
The machine is designed for sawing joists up to 36 in by 12 in at an angle of 45°. The saw carriage has a travel of 6 ft and cutting speeds are from 40 to 90 ft per minute in four steps. Feeds are from zero to 20 in per minute. The large table of the machine measures 9 ft 11 in by 2 ft 9½ in and the small table 7 ft 9 in by 1 ft 6 in. Power is supplied by a 15 h.p. motor running at 950 r.p.m.

The saw has segments of high speed steel rigidly fixed to the blade. The mounting on the spindle is to BESA Standard No. 387/1930. Nickel chromium steel has been used for the spindle which runs in gun-metal bearings and the carriage is of box construction with a long narrow guide. The saw is driven through a worm and double helical gearing totally enclosed in oil. The bed has adequate provision for the collection and removal of chips, and contains a tank in it for lubricant. The table is of large area and made in two pieces with the saw passing along the slot between them. Both tables have T slots.

The "Fluifeed" system has an oil pump delivering oil to a cylinder bolted to the bed. Any cutting rate can be obtained by moving a single lever. It is claimed that this system increases the life of the blade, as the rate of feed automatically adjusts itself to the section being cut. The carriage has a quick return motion and relief valves which are fitted in the oil system give protection in the event of a jam. The feed can be tripped at any chosen point by adjustable stops. *Noble and Lund Limited, Gateshead 10.*

SHAPING MACHINE

19½ in Stroke



A SHAPING machine with a stroke of 19½ in is a heavy model for general use, and is fitted with power operated downfeed.

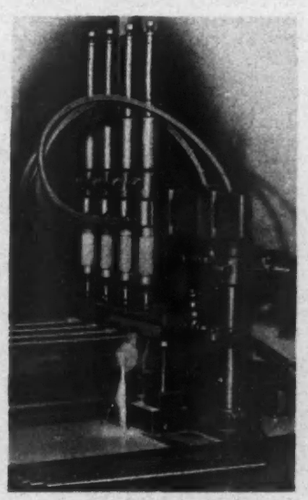
Both body and ram are of robust design and the body has dish-formed sides to resist deflection. It stands on a box-shaped base forming a trough for the lubricant and having the front machined to take table support. The ram is centrally driven by crank motion with a quick return action. Adjustments to the stroke can be made while the machine is running. The tool head is mounted on a swivel base and will turn through 180°; the end of the ram is indexed for setting.

The table is of box section and also swivels. It is bolted on the apron, using the T slots. Varying rates of power feeding are available up to 0·04 in per minute. The gearbox is built on the unit principle and provides six changes of speed from 9 to 88 strokes per minute; sliding gears are used, operated by two levers. A third lever operates the clutch.

The table has a horizontal traverse of 18 in and vertical movement of 15 in. Maximum distance of table from ram is 16 in. The feed of the tool box is 5¼ in. The top table measures 19 by 14½ in and the side is 15 in by 14 in. Power required is 4 h.p. and the driving pulley runs at 350 r.p.m. Floor space needed is 7 ft by 3 ft 6 in. *Crowthorne Engineering Company Limited, Atlas Works, Reddish, Nr. Stockport.*

UNIT DRILLS

Self Feeding



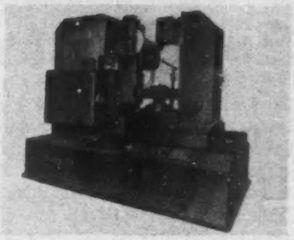
THE illustration shows a set-up of four "Selfeedrils" which are pneumatically operated and fed.

Only one air hose is required for each unit, controlled by a simple on/off valve. An air motor drives the drill chuck, and air pressure advances the forward feed. At the end of the set stroke the feed is reversed and the drill withdrawn from the work, still rotating. The cycle will not repeat until the air supply has been interrupted. An oil dashpot is incorporated in the system giving a two stage control for rapid approach and slow feed, with full break-through control.

The unit drills can be arranged in a variety of ways to suit particular applications. A wide selection of clips, columns and bars is available to form the mounting structures. As the drills have a small cross-section they can be mounted at close centre distances and several versions are made for different purposes and with different speeds. Tapping heads operating on the same principle are also made, which can be included in the same circuits as the drills. *R. S. Brookman Limited, Parkside Works, Rothley, Leicestershire.*

GEAR GRINDER

Wide Faces



THE special feature of the GC48 gear grinder is the wide face that can be cut—up to 12in.

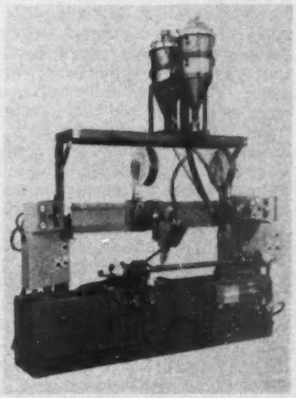
It has been particularly developed for traction gears which are wide faced and coarse pitched. The machine will work on gears with pitches up to 1·75 d.p. The maximum diameter that can be accommodated is 48 in or 28 in if centre mounted. Large pinion shafts can also be ground, using a detachable tailstock arrangement. Long shaft components can be taken by the hollow work spindle up to 6 in diameter.

The indexing system is the same as that used on other machines built by the firm, and the entire hydraulic system is separate from the machine itself, with Stein Atkinson Vickers equipment used throughout. A central control panel allows convenient operation from one position, but there is also duplication of controls where necessary for operating certain units from the back of the machine.

The trimmer unit is the 1 to 1 type, and two hardened and ground form plates shaped to the profile required on the gear teeth, control the path of the diamond tools over the grinding wheel. The trimmer for the root form has a diamond that is traversed over the complete fillet of the tooth. The radial setting dimension together with the arc of swing to join the involute and the flat are all controlled by limit switches and micrometer stops. Axial alignment is to within 0·0001 in per in face width; involute profile to 0·0003 in and adjacent tooth spacing to 0·0003 in. Cumulative spacing is within 0·001 in. *Gear Grinding Company Limited, Shirley, Solihull, Warwickshire.*

AUTOMATIC WELDER

Submerged Arc Process



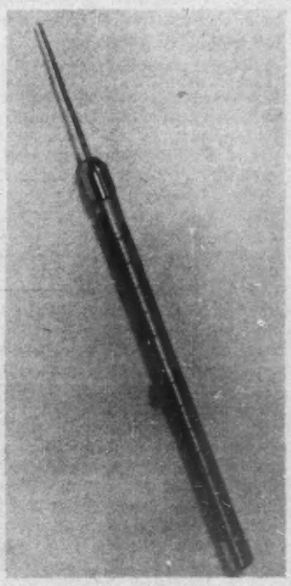
FURTHER improvements have been made to the Lincoln fully automatic submerged arc welder.

There are two forms of the head, one for stationary operation where the work is rotated or moved and the other where the head travels along the work as in the illustration. All controls face the operator and the station is hinged to the flux hopper for easy access to the feed wire mechanism. Standard or wide range speed controls are available to give travel speeds of 10 in to 90 in per minute in 3 to 1 ratios or 10 in to 200 in per minute in 20 to 1 ratios.

A new slide mechanism enables the welding head to be moved both vertically and horizontally. Wire feed gearbox, control station, and flux hopper can be rotated through 90° for welding circumferential seams. The correct volume of flux is ensured by a feed valve with a shroud covering nozzle and a feed tube to concentrate the flux shield. On the travelling model the wire reel holder has been moved to give greater stability. The point of welding is accurately illuminated by a special guide light. In general, the travelling head is the same as the fixed one but has a motorised carriage. Fillet and lap welding attachments can be easily added. *Lincoln Electric Company Limited, Welwyn Garden City, Hertfordshire.*

ORIFICE GAUGE

For Small Diameters



THE Matrix small hole gauge was originally designed for the rapid and accurate determination of the size of small orifices such as are used in oil burners.

In operation the tapered needle is inserted in the orifice and slid forward until a fit is obtained. The true diameter is then read from the scale. All working parts are made of hardened and ground tool steel.

Readings throughout the scale are within 0·0002 in and each division represents 0·001 in diameter. The graduations are sufficiently widely spaced to enable direct readings to be made to 0·0005 in. The standard range of gauges covers holes from 0·010 in diameter up to 0·5 in diameter in eight sizes. These are: 0·01 to 0·04 in; 0·03 to 0·08 in; 0·08 to 0·13 in; 0·13 to 0·18 in; 0·18 to 0·26 in; 0·26 to 0·34 in; 0·34 to 0·42 in and 0·42 to 0·50 in. *Coventry Gauge and Tool Company Limited, PO Box 39, Fletchamstead Highway, Coventry.*

Europe in the World Economy of Today

A decade of hard work and investment has carried Europe from post-war chaos to increasing production and affluence. The two big tasks ahead are expanding world trade and speeding the advance of the developing new nations.

IF ALL the reports published by international organisations were placed end to end they would look very foolish. Some of them indeed are none too bright to read in any case, but there are exceptions. Two that have appeared recently are the eleventh annual report of the OEEC, *Europe and the World Economy* (HMSO 9*s*) and the UN Economic Commission for Europe report on *Long Term Trends and Problems of the European Steel Industry* (HMSO 14*s*). Although the latter covers a more limited field the forecasts that it makes of steel production, consumption and trade in 1972-75 complement the stocktaking operation undertaken by the OEEC.

The past year is described as one of " balanced growth " in which the three goals of expansion, price stability and external balance were simultaneously achieved. As a result, the OEEC countries are now in a better position to shoulder their responsibilities in the world. OEEC defines these as ensuring continued expansion of world trade and accelerating the development of the less-advanced economies. In other words, the European countries have passed beyond the stage of post-war recovery in which they were preoccupied with their own problems. What are the essential conditions for securing the wider objectives laid down by the OEEC?

The most important factor is to ensure that economic growth takes place without wasting resources either of manpower, machinery or capital. The report gives the European countries full marks for their performance in this respect. Taking the OEEC countries as a whole the gross national product rose by over 4 per cent and industrial production by 7 per cent. However, there were a number of favourable circumstances in 1959 which may not recur. These were spare capacity, some slack in the labour market, fewer wage claims and only moderate increases in raw material prices. In 1960, OEEC warns that governments will be more concerned with the problem of checking excess demand and rising costs, as there is no longer any substantial amount of slack to be taken up. The Chancellor's recent hire purchase squeeze bears out this part of the forecast.

RATES OF RECOVERY

A year ago several of the European countries were still recovering from the recession of 1958. By mid-summer, however, most of them had passed their previous peak output and growth went on rapidly through the year.

Several factors helped this increase. Higher public works and building expenditure was one. Increased private saving and investment was another. In Britain the continued rise in consumption was an important item in recovery. One of the most interesting comparisons given in the OEEC report, and illustrated most dramatically by a page of graphs, is of employment conditions in the member countries.

Germany, Italy and Denmark suffered virtually no rise in unemployment during the 1958 recession. Only in Sweden, Norway and Britain did the figure rise above the 1952-53 levels. The number of vacant jobs rose steeply in Germany and Denmark throughout 1959. In Britain, Belgium and France unemployment was still higher in the autumn of last year than it had been eighteen months earlier. One aspect of the employment situation is that the average hours worked were falling in most OEEC countries during last year. In Germany, in particular, average paid hours in manufacturing industry fell from 48·8 per week in 1955 to 45·7 in 1958.

In discussing the performance and prospects of particular industries, the OEEC shows that the greatest impact of the 1958 recession was on steel, textiles, transport, shipping and coal. Recovery has brought a sharp increase in demand for steel and textiles, but demand for coal has stayed far below previous levels. Neither inland transport, nor shipping, have been able to shake off the effects of the previous year's set-back.

In the engineering industries output remained practically stationary in 1958, but started to pick up in the spring of 1959, and by November was 14 per cent higher than at the opening of the year. Nevertheless, the performance of individual industries varied widely.

Production of consumer durables rose strongly throughout both 1958 and 1959. And motor car output was 23 per cent higher in 1958 than in 1957. This outstanding gain was offset later and the rate of growth slowed down to 16 per cent during the latter half of 1959. All the main manufacturers exported more cars to North America. 1959 exports to that market represented 10 per cent of a total production of 4·1 million passenger cars.

Demand for investment goods which had fallen off in 1958 remained slack during the following year. Some revival of activity is now forecast by the OEEC in this field.

STEEL AND SHIPPING

Crude steel production fell by 10 per cent from its peak in the third quarter of 1957 to its trough in the fourth quarter of 1958. A vigorous recovery has taken place since the spring of 1959. Output in metal products industries has improved and there has been a rise in construction.

The running down of stocks came to an end in the middle of last year. The steel strike in the United States played a considerable part in clearing stocks in the OEEC countries.

The conclusions of the Economic Commission for Europe (ECE) cover a much wider field. ECE was concerned with world steel consumption and production in 1972 to 1975. An increase in investment in steel is called for if rates of increase of 3·5 per cent in W. Europe, 1·8 per cent in N. America, and 4·5 per cent in the USSR are to be achieved. The report argues that in 15 years time the size of blast furnaces will increase to a daily output of 4,000 to 5,000 tons, and the heat size of open-hearth furnaces will increase to between 900 and 1,000 tons, of electric furnaces to between 250 and 300 tons, and of converters from 200 to 300 tons. These increases together with the greater use of high capacity continuous rolling mills will bring down total investment cost per ton of iron and steel by 10 to 15 per cent.

Shipping, says the OEEC report, was one of the industries hardest hit by the recession of 1958. Bad forecasting of future demand was partly to blame. The sharp increase in world trade and the increase in freight rates in 1955 and 1956 led to optimistic ordering of new ships on the assumption that the demand for carriage of bulk products would go on increasing. The result was that much new tonnage became available in 1958 at the very time when demand for dry cargo shipping fell by 6 per cent. The volume of new construction in the world's shipyards rose from 11·2 million gross registered tons at the end of 1954 to a peak of 34·1 million in mid-1957. As a result of increased building the world fleet increased by 16 per cent between 1957 and 1959. For dry cargo vessels the increase was 10 per cent and for tankers 27 per cent. The drop in demand for tonnage, together with the new building, brought freight rates down below the levels at which some types of vessel could be operated at a profit. At the beginning of 1958 the laid-up fleet was over 9 million tons. This fell to 6·3 million tons by October, 1959. Of the OEEC countries' fleets, some 5 per cent is now laid up.

Looking ahead the report calculates that about one-third of the total dry cargo fleet (excluding the United States reserve fleet) is now 20 to 25 years old and may come up for scrapping in the next few years. Unless the rate of scrapping is stepped up, the present high level of building will continue to keep freights low. A new factor working against dry-cargo carrying tramps is the competition of tankers in the carriage of grain. So far as tankers are concerned, short-term prospects are affected by the existence of laid-up tonnage amounting to some 3 million gross registered tons. The projected pipelines from the Mediterranean ports and the growing importance of Saharan oil both introduce uncertainties into the longer-term pattern. The report asserts that the 1959 rate of building, at 4 to 5 million gross registered tons, was considerably in excess of probable long-term requirements.

In the OEEC countries the volume of ships under construction fell by 6 per cent between the peak reached in the third quarter of 1958 and the fourth quarter of 1959. The declines were concentrated in Germany, Italy and Britain. The fall from the peak was greater in the United States and Japan than elsewhere. The report states that it would be in the interests of shipbuilders themselves to come to an arrangement with shipowners to spread orders out over a larger period so as to help restore a better balance in the tanker market. At present, tankers account for about half of total shipbuilding. The decline in tanker building will entail a drop in employment in shipbuilding which will be severe, says the report, in areas of high cost production.

COMMON MARKET IMPACT

The part of the report which deals with the impact of the European Economy Community (the Common Market) provides a demonstration for those who still need it, that tariffs are not the only factor influencing trade. The first tariff cuts of 10 per cent made by the Six on 1 January, 1959, were extended to other members of GATT, and a 20 per cent liberalisation of quotas was also extended on a reciprocal basis to the other OEEC countries. Intra-Community trade following these changes rose during 1959 about twice as fast as trade between the Community and the other OEEC countries.

The French devaluation may also have affected the pattern of trade. There is no doubt that a great part of the increase was due to increased sales efforts within the Six in anticipation of more rapid development of export markets there in the years ahead. Trade between countries outside the Community recovered less rapidly in 1959 than either trade between the Six, or trade between the two groups. The biggest increases in intra-EEC trade up to the summer of 1959 were the rise in German imports and the expansion of French exports. It is interesting that over half of these were exports to Germany. Over two-thirds of the manufactured goods entering into intra-European trade were exported by the Community countries.

It is cause for concern that *Europe and the World Economy* will be the last annual report of the OEEC as at present constituted. The report of the four wise men *A Re-modelled Economic Organisation* proposes the running down of the present organisation and its replacement by an Organisation for Economic Cooperation and Development whose main task would apparently be to coordinate economic aid to the less developed countries. All those who have taken part in the work of the OEEC industrial committees, as well as the thousands more who have profited from reading its reports, will find in all this a great deal to regret.

Controversial Costing

NUCLEAR power economics can be influenced in three ways: through lowering the capital cost, through improving plant utilisation, or through reducing the cost of fuel. Each method of approach has serious limitations, and in general all three are attempted in any design to achieve economic power production. At the World Power Conference, Madrid, the technical session IV B was devoted to the economic and social factors in the commercial-scale erection of nuclear reactors, and produced some spirited controversy during the discussion period.

New System to Break Through the Cost Barrier

As the production cost of nuclear power stations is divided roughly in the ratio of 2 to 1 between capital and running costs, it would appear that attacking the capital cost of power stations would produce the most immediate results. Unfortunately, for any given reactor system the attempts at cost reduction tend to produce results which are asymptotic to a well defined minimum. Taking the example of gas-cooled reactors, discussed in the paper of R. D. Vaughan of the Nuclear Power Plant Company,

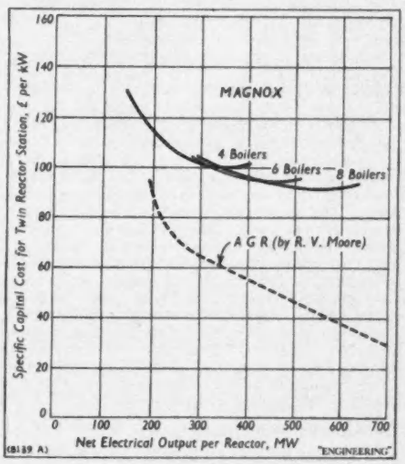


Fig. 1 Effect of output on plant cost.

"The Technical and Economic Development of the Gas-Cooled Reactor," attempts to raise the coolant pressure or to increase the total plant rating suffer severely from the laws of dimishing returns in the range of pressures and ratings which have already been reached. Figs. 1 and 2, taken from the paper of Vaughan, show the effects in terms of plant size and production cost. It is then immediately suggested that to improve plant economics, different more advanced reactor systems must be considered. This approach has been adopted by the United Kingdom Atomic Energy Authority in developing the Advanced Gas-cooled Reactor. R. V. Moore of the UKAEA amended Vaughan's graphs as shown in the figures during the discussion period to show that the cost curves of the AGR do not become asymptotic in the range of reactor plants presently considered for installation even in the largest integrated electrical system, that of the Central Electricity Generating Board.

Development Costs May Outweigh Gains

But changing the reactor system is a very expensive solution. It means that a development and engineering test programme of impressive proportions must be initiated, which will cost far more than can be saved through reduced costs on several stations built in accordance with the advanced techniques. Dr. H. S. Arms of English Electric said that while the figures of Vaughan were all based on firm tenders which the consortia were willing to back up, it would take some £20 million to verify a single point on Moore's amendment. If viewed in terms of the total national economy, it requires some very clear thinking to justify the expenditure of starting the development of a new reactor system before the predecessor has yielded sufficient results, even though it will be known in engineering circles years in advance that the new system would be cheaper and more economical if only the cost of electricity were considered.

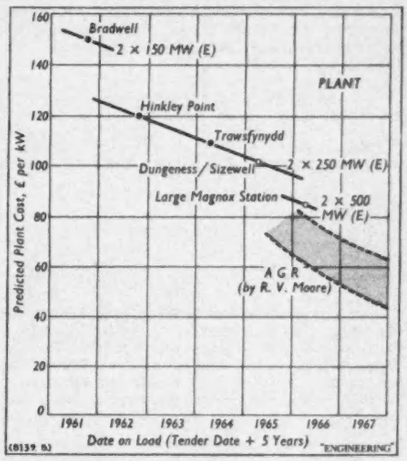


Fig. 2 Reduction in plant costs with time.

Losses Must be Considered

But even those cost figures in Vaughan's graph which were based on firm tenders were challenged by A. E. Powell of Merz and McLellan, who claimed that the so-called "advances" on which the price reductions in subsequent CEGB tenders relied, were based on untried techniques, and should be regarded with some caution. To this perhaps should be added the fact, not mentioned by Powell, that experience has proved some of the tenders to be unrealistic and losses as high as £3 million have been quoted by the consorita. Such a loss would make a difference of £10 per installed kW on a 300 MW(e) station such as Hunterston, while the profit or loss on the later larger stations has not yet been added up. Thus the real cost of nuclear stations to the United Kingdom economy may be quite different from the curves shown in Fig. 1 and Fig. 2. R. D. Vaughan defended his conclusions by pointing out that although the advances from station to station had not been proved in operating reactors, the consortia had extensive testing programmes in which important and expensive plant components were evaluated under conditions resembling reactor operation. An important example was the charge-face equipment, which had no precedent at Calder Hall. Nevertheless great changes have occurred from the first civil station to Dungeness and Sizewell, and these changes have been fully justified by component test programmes.

Economic AGR Size

Sir Christopher Hinton used Moore's curves to explain a statement in the joint Hinton, Brown and Rotherham paper "The Economics of Nuclear Power in Great Britain," which was interpreted as saying that the first commercial application of the AGR would be in a 600 to 800 MW (e) reactor installation. Admitting that the sentence construction permitted such interpretation, Sir Christopher emphasised that the figures resulted from assuming that the AGR core would be of the same size as that of the latest Magnox reactors. Referring to Moore's curve, he nevertheless admitted that the CEGB was thinking in terms of very large AGR stations because the important cost reductions could be realised only through bold engineering. To quote from the Hinton, Brown and Rotherham paper, arguments against such a large first installation are dismissed as follows: "The argument would not be unreasonable but for the fact that reduction of core size is almost bound to lead to an increase in fuel enrichment as well as to an increase in capital cost, and thereby reduce the attractiveness of the uranium-oxide fuelled system." Whether Oldbury will be an AGR or not, it appears that the first AGR station will be bigger than anything attempted before, and the signs point to 500 MW (e).

Load Factor Redefined

Improved utilisation is the second standard approach to lower costs. Sr. Ortega Costa summarised the available methods: energy accumulation; inducement of off-peak consumption by a differential price policy; interconnection of systems with a phase difference in the energy demand curves; and external compulsion to change consumption habits. Sr. Ortega was of the opinion that differential prices and governmental action to induce changes in consumption (for example staggered working shifts) have been underrated as methods of improving the utilisation of generating capacity. In this connection a great deal of confusion in terminology exists. Donald Clark of the CEGB felt that the terminology needed to be redefined to avoid the confusion that existed between various papers. According to Donald Clark, the "load factor" is a property of the electrical distribution system, while "availability" is a property of the generating equipment. The "utilisation" of a plant is the fraction of time in which a plant can be operated gainfully, and is defined by the system's load factor on the one hand, and the plant's availability on the other.

Staggered Construction

While utilisation is the important parameter from an economic point of view, the plant designer has only limited control over this figure, in that the plant's availability will define the maximum utilisation attainable. But availability will not *guarantee* utilisation, and Dr. Arms felt that nuclear plants must be designed for a realistic utilisation factor. The assumed value of 75 per cent utilisation in a paper "Siting of India's First Atomic Power Station," by M. N. Chakravarti and M. R. Sirinvasan was contested both by A. E. Powell and Geoffrey Kennedy of Kennedy and Donkin. The Indian system, in which a 75 per cent utilisation is assumed for a 300 MW(e) plant, has a total capacity of only 1,600 MW. Mr. Kennedy also felt that the Indian suggestion of building a two-reactor station in two stages separated by an interval of several years was unrealistic, and the contractor's charges for moving to the site twice would outweigh the gains from the higher utilisation of the first plant during the initial period. Mr. Nair Nayar, speaking for the authors of the paper, replied that the choice of two 150 MW(e) reactors was dictated by the smallness of the system which would suffer seriously if more than 150 MW were dropped as a result of circuit breakers opening. Referring to the utilisation factor, Mr. Nayar felt that since the present load factor was in fact 75 per cent on the system, there would be no difficulty in maintaining the same with a nuclear reactor.

Thermal Storage and Fossil Superheat

Thermal storage schemes were again discussed in detail. (Atomic Review, 10 June, '60.) Conflict between two papers, by the father and son team of Professor and Dr. Marguerre of Germany and F. A. P. M. Theunissen of Royal Dutch-Shell, was pointed out repeatedly. Drs. Marguerre claimed $45 per kW for thermal storage installation costs, Theunissen's figure was $80. The capital cost figures were challenged by Basil Wood and Geoffrey Kennedy. A. E. Powell, commenting on hybrid stations (nuclear evaporator with fossil fuel superheater) suggested that such stations could be built in two stages, first the nuclear plant, and at a later date the superheaters could be added. Basil Wood claimed that it was bad engineering to build stations operating on saturated steam since the addition of superheating is a cheap way of obtaining more power.

Long Term Consequences

The third aspect of nuclear power economy is the question of fuel cost and fuel utilisation. That the two are intimately connected with each other is illustrated by the paper of H. Cartwright of the UKAEA, "The Factors Influencing the Development of a Nuclear Power Programme." Cartwright's paper is an analysis of the consequences which follow the decision by any country to develop a nuclear power programme in any particular way. Fig. 3 illustrates the present range of possibilities in which the natural uranium, enriched uranium, and breeder reactors are linked by their fuel cycles. It is emphasised that in a national power programme the most important consideration may not be the capital and production cost of any particular installation, but the overall production cost from an integrated system such as shown in Fig. 3, which may belong to a single country or may extend over several.

High Grade and Low Grade Resources

The same argument was discussed by Dr. Walter H. Zinn and Dr. J. R. Dietrich of Combustion Engineering and General Nuclear Engineering Corporation respectively, in their joint paper "Nuclear Fuel Resources and Reactor Fuel Costs." Zinn and Dietrich argue from the point of view of the availability of high-grade and low-grade ores, and the efficiency with which the fissile material contained or derived from the ore by the various fuel cycles is turned into useful energy. The analysis, although

detailed, is of necessity based on a series of assumptions regarding future trends in nuclear engineering, and some of these assumptions were later contested by members of the French and U K delegations.

Biased Assumptions?

It is tentatively assumed that all fissile isotopes have equal value from the point of view of fuel utilisation. The standard of comparison is therefore the amount of heat in megawatt days (MWD) produced per gramme of fissile isotope lost, and in this connection "loss" may be either fission or dilution of the fissile isotope to an unrecoverable degree. Thus the 0·22 per cent of uranium 235 contained in the depleted stream of a gaseous diffusion process is considered lost. Similarly, the uranium 235 contained in the irradiated fuel of natural uranium reactors is also considered lost, although the plutonium content is recovered. But all uranium 235 in enriched fuel is assumed recoverable. Table I shows the results of the calculations for four distinct thermal-reactor types: a natural-uranium graphite-moderated reactor, a water-moderated reactor, and two uranium-oxide fuelled heavy-water moderated gas-cooled reactors, one using natural, the other slightly enriched fuel.

TABLE I.—*Utilisation of Fuel and Fissionable Isotope in Several Reactors*

	GCR	PWR, BWR	HWGCR	
Reactor feed enrichment, per cent U-235	0·72	1·91	0·72	1·00
Average conversion ratio	0·75	0·68	0·79	0·77
Fuel irradiation, MWd per ton	3,000	15,000	8,150	16,500
Tons natural U mined per ton of feed fuel	1·00	2·80	1·00	1·56
Fuel utilization, MWd per ton natural U mined	3,000	5,400	8,150	10,600
Fissionable isotope loss and production, grams per gram of U-235 in rector feed:				
U-235 discarded by diffusion plant	0	0·32	0	0·12
U-235 destroyed by fission and neutron capture	0·42	0·73	0·80	0·95
U-235 in spent fuel	0·58	(0·27)*	0·20	0·05
Total U-235 made unavailable	1·00	1·05	1·00	1·12
Net fissionable Pu produced	0·25	0·37	0·42	0·33
Net loss of fissionable isotope	0·75	0·68	0·58	0·79
MWd of heat produced per gram U-235 in feed	0·46	0·87	1·25	1·82
MWd of heat produced per gram of fissionable isotope lost = utilisation of fissionable isotope	0·61	1·28	2·15	2·30

* Recycled

Future Prosperity at Stake

From this comparison the gas-cooled reactor comes out poorest. Zinn and Dietrich emphasised that fuel utilisation is not important because of any limitations on the availability of uranium and thorium ores. "The present incentive for fuel conservation is a concern for the future economics of nuclear power generation rather than a fear of the actual exhaustion of nuclear fuel sources." The argument is that once the *concentrated* ores are exhausted—which is a relatively short-term possibility—the picture of fuel economics will undergo a radical change. The important questions are then: how soon will the concentrated ores be exhausted, and how much will it cost to utilise the remaining resources. The last figures in the table from Zinn and Dietrich hold the answer to the former question, and this answer is decidedly unfavourable to the graphite-moderated reactor.

Stung into Reaction

Thus the two papers, one by Cartwright and the other by Zinn and Dietrich, are virtually complementary. Both discuss the long-term economic consequences of the early choice of reactor systems in terms of the possible fuel cycles that can be employed. But the implication of Zinn and Dietrich is that gas-cooled graphite moderated reactors are not a wise choice if viewed in terms of a nation's future prosperity. In view of strong United Kingdom and French representation, such implications could not remain unchallenged, and the occasion was only spoiled by the absence of both Dr. Zinn and Dr. Dietrich from the session.

Fuel Costs

M. Domenjoud of France opened the discussion. In the paper by Zinn and Dietrich the fuel costs were calculated for various reactor types, based on a fabrication cost of $140 per kg of uranium. M. Domenjoud pointed out that Canadian prices for fabrication are much lower than $140, and that in any case if viewed over a long period, the fabrication costs are bound to fall. Recalculating the figures of Zinn and Dietrich for lowered fuel costs, Table II can be compiled.

TABLE II.—*Fuel Costs for Three Reactor Systems*

Fabrication cost, $ per kg uranium	Light water reactor	Natural uranium heavy-water reactor	Slightly enriched heavy-water reactor
$140 (Zinn and Dietrich)	2·65	2·79	1·81
$100 (Domenjoud)	2·24	2·16	1·46
$60 (Domenjoud)	1·84	1·51	1·11

Mills per kWh

It can be seen that falling fabrication costs favour the natural uranium reactor, and that the order of merit is reversed between the enriched-fuel light-water reactor and the natural-fuel heavy-water reactor when the cost drops to $60 per kg uranium. In addition, M. Domenjoud pointed out that a drop in plutonium credit—possible through a change in military policy—would tend to favour the reactors least affected by plutonium repurchase prices, that is, the natural uranium reactors.

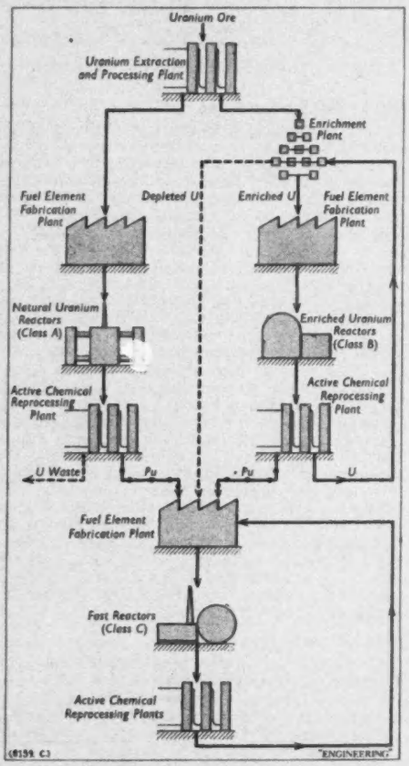


Fig. 3 How nuclear power stations are interconnected by their fuel requirement.

Most Controversial

M. Domenjoud was followed by Mr. Kennedy. Quoting verbatim: "I feel personally that the figures used in the analysis [of Zinn and Dietrich] are most controversial, and show too much favour to the enriched-uranium reactors. I feel that the figures used show that the fuel enrichment (of water reactors) is very low, at the same time the burnup assumption is higher than is generally thought reasonable. Either heavy fuel cladding should be assumed in order to achieve this burnup, and this in turn means much greater enrichment, or the burnup assumptions should on the other hand be reduced. . . . It is assumed [by Zinn and Dietrich] that the remaining uranium 235 in the irradiated natural fuel elements is useless, but that that remaining in an enriched element is all recovered. . . . If all these figures, which are biased in the same way, are adjusted in the other direction, it can be shown that natural-uranium reactors make the best use of uranium 235 resources." In the absence of Dr. Zinn and Dr. Dietrich from the technical session an opportunity for a most exciting clash of interests was lost. But it may be certain that the last word has not yet been spoken.

Notes and News

German Misgivings on US-Euratom Programme

The unpopularity of the US-Euratom joint nuclear programme in Germany was partly explained by H. E. Kahl at the recent sectional meeting in Madrid of the World Power Conference. West German utility companies were, he said, privately owned and tended to be small. Without interconnection their size was usually below 1,000 MW, so that without considerable government pressure and financial assistance, these companies would find it very difficult to make economic use of a nuclear station of 180 MW(e) capacity, the minimum considered in the US-Euratom scheme. Hence the lack of enthusiasm, which Professor Ludwig Ehrhard's economic policy of non-intervention in the private sector did not help to restore.

Safe Nuclear Ships and Design Secrecy

Proposals for the safety of nuclear ships have been approved by the International Conference on Safety of Life at Sea, which ended last week. But they were approved not unanimously. The leader of the British delegation had recommended that each ship should carry a "Safety Assessment," giving details of design affecting both the ship and its reactor, operation and control procedures, radiation protection, waste disposal, fuelling, manning, training requirements and the like. Governments of countries concerned, he said, must be able to satisfy themselves that the vessel and its nuclear equipment were safe before entering their harbours and waterways. The Soviet delegation considered that such a procedure was unnecessary and merely a pretext to secure information concerning Soviet designs. He said that the proposal would hinder marine reactor development, for shipowners would tend to use conventional systems instead of new techniques. "The Soviet delegation cannot agree to a provision that would prohibit or inhibit the building of nuclear ships." The draft regulations were nevertheless approved by 29 votes to 5, and will go forward with other recommendations of the conference for ratification by individual governments.

Strontium 90 Direct Power Source

A system for producing electrical power safely from tightly sealed pellets of a strontium 90 compound has been described by James J. Keenan, of the Martin Company. Speaking at the American Nuclear Society's meeting in Chicago, he said that heat produced by normal radioactive decay in about a pound of the compound could be converted directly into five watts of continuous electrical energy by a series of thermoelectric elements surrounding the fuel capsule. The unit could operate without maintenance or refuelling for several years. He also described elaborate safety precautions incorporated in the design, which has been evolved by the company's Nuclear Division. The generator is designed to withstand a plane crash or explosion without releasing its fuel. Secondly, the pellets themselves are to be surrounded by three layers of a material called Hastelloy-C, which is said to be so corrosion-resistant that it would provide protection against sea water for centuries. Finally, the fuel compound envisioned is strontium titanate, which is itself virtually insoluble in water. (The peculiar biological problems usually associated with strontium 90 arise if it is absorbed by a living organism in soluble form.) Keenan, who was co-author of the paper with two other Martin engineers—George P. Dix and Cecil O Riggs—said that the simplicity, reliability and long operating life of a strontium 90 generator would make it ideal for, many uses. It might serve to operate channel buoys unmanned scientific data recording stations in remote areas, or various devices to aid navigation.

Too Hot for Wells Fargo?

Described as "the shortest and hottest working railroad in the world," an O-gauge toy railway system is used to carry samples into an experimental hole in the University of Michigan's research reactor. The locomotive enters a tunnel in the concrete reactor shielding and emerges, presumably, unscathed. Professor Paul Chagnon stated that, at £4 16*s*, this approach gave the cheapest solution to the problem. "Our biggest headache," he said "was getting the request for a toy engine past our purchasing department."

CHIEF ENGINEER

for the main mill of an independent company of fine paper manufacturers in the North-West employing 1100. This is a substantial company operating very modern plant by up-to-date management practices in attractive surroundings. Starting salary £1750-£2250 together with a car. Pension Scheme. Residential facilities are excellent and conveyance charges and cost of furniture removal will be met.

The Chief Engineer will report to the Director of Engineering and be responsible for the organisation and control of a substantial maintenance department. The essence of this appointment is to ensure that the very modern equipment of the mill is in condition to operate continuously 7 days per week, 50 weeks per year, and that the cost of maintenance is economic. In addition, there is a considerable amount of development and enlargement work to be carried out in the foreseeable future, in the main by company labour.

Among the desired qualifications are not less than 7 years' experience in control of the maintenance of paper-making machinery, including continuous 7-day operation; personal experience of the operation of planned maintenance; first class professional qualifications required. Age 35-40 years.

Please write briefly in first instance, quoting Reference No. 752 to:—

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ASHLEY ASSOCIATES LTD.
PETER HOUSE, MANCHESTER 1.
RETAINED TO ADVISE ON THIS APPOINTMENT
The strictest confidence will be observed and no details of candidates will be passed to clients without candidates' permission.

C 387

'Engineering' Appointments Section

PUBLIC APPOINTMENTS

INSTRUCTORS GRADE III

INSTRUCTORS GRADE III required for W.D. ESTABLISHMENT — Main Trade Ammunition Inspection and Repair. Salary £805 at 26 rising to £1000 p.a. Candidates will be required to (1) Inspect a complete package of Cartridges QF fixed, Mortar Ammunition or Cartridges BL, giving a step by step instructional commentary to a class of students. (2) Criticise an ammunition repair workshop layout and suggest an improved flow line, executing in detail any technical operation selected by the examiners. (3) Give a 20-minute lecture at candidate's choice on either (*a*) the Development of armour piercing projectiles, or (*b*) the general principles of ammunition care and maintenance, or (*c*) the make-up and functioning of a typical round of QF fixed HE DA Fused Ammunition.—ALL APPLICATIONS IN WRITING TO THE MANAGER, EMPLOYMENT EXCHANGE, CHEPSTOW, MONMOUTHSHIRE. C 352

ASSISTANT TECHNICAL COST OFFICERS

MINISTRY OF AVIATION requires ASSISTANT TECHNICAL COST OFFICERS in London to prepare estimates of prime costs of manufacture of engineering productions. Duties normally involve a considerable amount of travelling. Qualifications: Recognised engineering apprenticeship or equivalent training in an appropriate trade. Good practical experience in rate-fixing, operational planning and prime cost estimating of engineering productions. Vacancies exist in various Sections dealing with high class mechanical and electrical productions, aircraft, instruments, electronic equipments or work which requires very good machine shop experience. Salary £900 (age 30) to £1065 p.a.—Application forms from MANAGER (P.E.16), MINISTRY OF LABOUR, PROFESSIONAL AND EXECUTIVE REGISTER, ATLANTIC HOUSE, FARRINGDON STREET, LONDON, E.C.4. C 351

THE UNIVERSITY OF LIVERPOOL

Applications are invited for the post of LECTURER in the DEPARTMENT OF MECHANICAL ENGINEERING. The initial salary will be within the range £1060-£1350 per annum, according to age, qualifications and experience. Candidates should have a good Honours degree and experience in the general field of Applied Mechanics would be an advantage.

Applications, stating age, academic qualifications and experience, together with the names of three referees, and quoting reference No. CV/En, should be received not later than 9th JULY, 1960, by the REGISTRAR, from whom further particulars of the conditions of appointment may be obtained. C 349

EXPERIMENTAL OFFICER

EXPERIMENTAL OFFICER required at the NATIONAL INSTITUTE OF AGRICULTURAL ENGINEERING to work in co-operation with the DEPARTMENT OF HOP RESEARCH, WYE COLLEGE (UNIVERSITY OF LONDON) on engineering problems connected with the mechanisation of hops and hop drying. Applicants should possess degree in engineering or in agriculture, with engineering aptitude, or N.D.Agr.E. Experience of research work desirable. Minimum age 28 years; superannuation. Salary scale £954-£1166. —Application forms from the SECRETARY, N.I.A.E., SILSOE, BEDS. C 361

UNIVERSITY OF DURHAM
KING'S COLLEGE
NEWCASTLE UPON TYNE, 1
DEPARTMENT OF CIVIL ENGINEERING
RESEARCH ASSISTANT IN
PUBLIC HEALTH ENGINEERING

THE COUNCIL OF KING'S COLLEGE invite applications for a RESEARCH ASSISTANTSHIP IN PUBLIC HEALTH ENGINEERING in the Department of Civil Engineering.

Candidates should be graduates of a British University in Civil Engineering. The appointment, which will be for one year in the first instance, may be renewed annually up to a total of three years. The commencing salary will be determined at an appropriate point within the range £560-£700 per annum according to qualifications and experience.

Further particulars may be obtained from the REGISTRAR OF KING'S COLLEGE to whom applications, together with the names and addresses of three referees, should be addressed so as to reach him not later than 23rd JULY, 1960. C 366

CENTRAL ELECTRICITY GENERATING BOARD
EASTERN DIVISION

Applications are invited for the following appointment in the ELECTRICAL DEPARTMENT AT DIVISIONAL HEADQUARTERS (COCKFOSTERS, NORTH LONDON).

THIRD ASSISTANT ENGINEER
(CIVIL AND MECHANICAL)

Salary, N.J.B., Class AX/DX, Grade 6, £975 by £25 to £1100/£1190 per annum inclusive of London Weighting.

The successful applicant will be required to assist in the supervision of Contracts for the installation of overhead lines constructed on steel towers and for foundations and site works for transmission substations, and should have received the appropriate training for such duties.

Applications, quoting Reference S.V. No. 1359, stating age, qualifications, experience and present position, should be sent to the CONTROLLER, CENTRAL ELECTRICITY GENERATING BOARD, EASTERN DIVISION, WEST FARM PLACE, CHALK LANE, COCKFOSTERS, BARNET, HERTS, to arrive not later than 2nd JULY, 1960. C 363

UNIVERSITY OF LONDON
READERSHIP IN ELECTRIC TRACTION
AT IMPERIAL COLLEGE

The Senate invite applications for the READERSHIP IN ELECTRIC TRACTION tenable at the Imperial College of Science and Technology (salary £1675-£1975-£2475 a year plus £80 London Allowance). Knowledge of Electrical Engineering including machines is of more importance than extent of experience in Traction.

Applications (10 copies) must be received not later than 12th SEPTEMBER, 1960, by the ACADEMIC REGISTRAR, UNIVERSITY OF LONDON, SENATE HOUSE, W.C.1, from whom further particulars may be obtained. C 362

CENTRAL ELECTRICITY GENERATING BOARD
EASTERN DIVISION

Applications are invited for the following appointment at Divisional Headquarters (Cockfosters in North London):—

DRAUGHTSMAN

Salary: N.J.B., Schedule D, Grade 5, £830 by £20 to £940 per annum; or Grade 6, £660 by £20 to £780 per annum.

The grade and commencing salary will be within the above ranges at a point commensurate with qualifications and experience.

The duties of the applicant appointed will include work on the layouts for high voltage transmission lines, substations and electrical diagrams.

Applicants should have technical qualifications to the standard of Ordinary National Certificate and should have had experience of this type of work.

Applications, quoting S.V. No. 1287, stating age, qualifications, experience and present position, should be sent to the CONTROLLER, CENTRAL ELECTRICITY GENERATING BOARD, EASTERN DIVISION, WEST FARM PLACE, CHALK LANE, COCKFOSTERS, BARNET, HERTS, to arrive not later than 9th JULY, 1960. C 381

MIDDLESEX COUNTY COUNCIL
EDUCATION COMMITTEE
SOUTHALL TECHNICAL COLLEGE
BEACONSFIELD ROAD
SOUTHALL, MIDDLESEX

Required 1st SEPTEMBER, 1960, or as soon as possible afterwards, ASSISTANT GRADE "B" to teach Engineering Science and Drawing up to Final level in Machine Shop Engineering Courses. Ability to offer Workshop Technique and Practice would be an advantage. Good industrial and/or teaching experience desirable.

Salary within the range (men):—

Graduate, £828 to £1486 per annum.

Non-Graduate, £738 to £1201 per annum.

Forms of application and further particulars may be obtained from the PRINCIPAL (foolscap s.a.e.), to whom completed forms should be returned WITHIN 14 DAYS of the appearance of this advertisement.

C. E. GURR, M.Sc., Ph.D.,
Secretary to the Education Committee. C 375

CENTRAL ELECTRICITY GENERATING BOARD

PLANNING DEPARTMENT

Headquarters, London, S.E.1.

SENIOR ASSISTANT ENGINEER (HYDRO-ELECTRIC)

required in the **Hydro, Industrial and District Heating Section of the Station Planning and Development Branch.**

The Section is concerned with the planning of new hydro-electric generating plant in England and Wales. It is responsible for the investigation and selection of sites for hydro-electric and related projects including their economic assessment and subsequently their evolution in principle. It is also responsible for the negotiations for statutory and other consents.

The engineer appointed to this position would be responsible to the Hydro, Industrial and District Heating Engineer. Candidates should possess an Honours degree or the requisite qualifications for corporate membership for the Institutions of Civil, Mechanical or Electrical Engineers. A sound engineering or scientific background in hydro-electric work is essential. It will also be an advantage if candidates have been engaged in the preparation of initial project reports and estimates for such schemes and/or have experience in hydro-electric construction.

Salary within the range £1,590-£1,940 p.a.

Applications stating age, qualifications, experience, present position and salary, to the Personnel Officer, 24/30, Holborn, London, E.C.1, by 4th July. Envelopes should be marked "Confidential Ref. ENG/220."

C 373

QUALIFIED ENGINEER

BRITISH TRANSPORT COMMISSION

Require

in the department of the CHIEF ELECTRICAL ENGINEER, MELBURY TERRACE, MARYLEBONE, LONDON, N.W.1, a **QUALIFIED ENGINEER** to assist in the specification and design of the overhead line contact system, including supports and ancillary equipment, for A.C. railway electrification. Experience in design and installation of the catenary system particularly desirable.

Salary range £1095 to £1210

Superannuation Scheme, certain travel facilities, medical examination. Write stating age, qualifications and experience to the

DIRECTOR OF ESTABLISHMENT
BRITISH TRANSPORT COMMISSION
222 MARYLEBONE ROAD
LONDON, N.W.1

within 14 DAYS.

C 348

PROFESSIONAL ENGINEER

required at

ATOMIC ENERGY RESEARCH ESTABLISHMENT, HARWELL

To assist in the organisation and control of:—

1. The mechanical installation and servicing of experimental apparatus, bubble chambers and related plant associated with the 7GeV Proton Synchrotron and allied Laboratories.

2. Precision survey and alignment of the main plant and experimental equipment.

Applicants should have served an engineering apprenticeship and experience in metrology and the use of optical measuring instruments would be an advantage.

SALARY: £860 (at age 25) to £1340 p.a.

Housing and superannuation schemes.

Send POSTCARD for details to:—

PERSONNEL MANAGER (1724/26), U.K.A.E.A., A.E.R.E.,
HARWELL, DIDCOT, BERKS.

C 350

CITY OF SHEFFIELD
EDUCATION COMMITTEE
COLLEGE OF TECHNOLOGY
DEPARTMENT OF ENGINEERING

Applicants for the following posts should hold graduate or equivalent qualifications and be adequately experienced in both industry and in teaching.

(*a*) SENIOR LECTURER IN PRODUCTION ENGINEERING (NEW APPOINTMENT)

The person appointed will be expected to teach Machine Tool Theory, Metrology and other Production Engineering subjects of the new scheme of the Institution of Production Engineers to Higher National Certificate and Higher National Diploma students. He will be responsible for the new, very well-equipped Machine Tool and Metrology laboratories. He will be expected to assist in the promotion of research and laboratory work in production engineering subjects, in the development of the Higher National Diploma course and in organising special advanced courses in production subjects. An interest in the application of automatic control to manufacturing equipment will be welcomed.

The following vacancies arise from the appointment of the present holders to higher posts. Corporate membership of the Institution of Mechanical Engineers is essential for both posts.

(*b*) SENIOR LECTURER IN MECHANICAL ENGINEERING

The holder of this post will be required to teach Strength and Properties of Materials and Applied Mechanics A1 and S3 in Higher National Diploma, Higher National and Ordinary National Certificate courses. He will be responsible for the Strength of Materials laboratory and will be expected to assist in the promotion of research, laboratory project work and special advanced courses in relevant subjects. Interest in and knowledge of experimental work in the mechanical deformation of metals will be welcomed.

(*c*) SENIOR LECTURER IN MECHANICAL ENGINEERING

The holder of this post will be required to teach Theory of Machines and Applied Mechanics A1 and S3 in the Higher National Diploma, Higher National and Ordinary National Certificate courses. He will be responsible for the Theory of Machines and Applied Mechanics laboratories and will be expected to assist in the promotion of research, laboratory project work and special advanced courses in relevant subjects. A knowledge of and interest in automatic control devices will be welcomed.

It is desirable that the successful candidates should take up duties on 1st September, 1960.

Salary: £1550 by £50 to £1750 per annum.

Application forms, obtainable from the undersigned (s.a.e.) at P.O. BOX 67, SHEFFIELD, 1, should be returned WITHIN 14 DAYS of the appearance of this advertisement.

T. H. TUNN,
Director of Education. C 371

NORTHAMPTON COLLEGE
OF ADVANCED TECHNOLOGY

St. John St., London, E.3.1

requires

(1) LECTURERS and SENIOR LECTURERS with honours degrees and industrial or research experience for the following subjects:
MECHANICS OF FLUIDS
MECHANICS OF MACHINES
APPLIED THERMODYNAMICS
STRENGTH OF MATERIALS

(2) ASSISTANT LECTURER in ENGINEERING DRAWING, preferably with degree or equivalent, and industrial experience.

These vacancies arise from the continued expansion of the College in Degree, Diploma in Technology, and post-graduate studies.

Salary scales:
Senior Lecturer, £1588 rising to £1801,
Lecturer, £1408 rising to £1601,
Assistant Lecturer, initially in range £828 to £1263, rising to £1291 to £1396.

Particulars and forms of application are obtainable from the SECRETARY. C 342

STANDARDS ENGINEER

is required by the

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

at

Windscale and Calder Works, Cumberland

to be responsible to the Chief Design Engineer for establishing, and the implementation of, standards and specifications for a wide range of mechanical and electronic equipment.

Applicants must have served a recognised engineering apprenticeship or have had comparable training and be corporate members of a senior engineering institution or equivalent. An electrical qualification or experience of electrical work would be an advantage. It is essential that applicants should have the knowledge, experience and personal qualities required to set up a Standards Organisation, wide general experience in practical engineering and specialised experience in standardisation.

Salary within the scale £1880 to £2180 according to qualifications and experience.

Contributory Superannuation. Staff Housing Scheme.

Send postcard for application form, quoting reference F/W.32/J2, to RECRUITMENT OFFICER, U.K.A.E.A. PRODUCTION GROUP, WINDSCALE WORKS, SELLAFIELD, SEASCALE, CUMBERLAND.

Closing date: 25th JULY, 1960. C 394

SENIOR LECTURER

ROYAL NAVAL COLLEGE, GREENWICH: SENIOR LECTURER IN MATHEMATICS. Pensionable post for man at least 26 on 1.1.60 with 1st or 2nd class honours degree in Mathematics. Teaching experience in both pure and applied mathematics essential. Appointment in September, 1960, or soon as possible thereafter. Salary scale £1233-£1460. Starting salary may be above minimum. Single accommodation available.—Write CIVIL SERVICE COMMISSION, 17 NORTH AUDLEY STREET, LONDON, W.1, for application form, quoting 8/5154/60. Closing date 21st JULY, 1960. C 382

GRADUATE RESEARCH ASSISTANTS

are required by

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY

St. John St., London, E.C.1

or projects in Applied Photoelasticity, Fatigue of Metals and Impact Testing. Those appointed will be expected to work for a Higher Degree of London University. Salary about £500 per annum including payment for some assistance in laboratory and tutorial classes. Candidates graduating this year will be considered.

Further particulars and application forms are obtainable from the Secretary. C 345

DESIGNER DRAUGHTSMEN

AIR MINISTRY, Works Designs Branch, requires in LONDON, STRUCTURAL ENGINEERING DESIGNER DRAUGHTSMEN for reinforced concrete or structural steelwork of all types. Applicants must have adequate training and several years' experience. Some site experience and possession of recognised technical qualification an advantage. Financial assistance and time off may be allowed for recognised courses of study. Promotion and pension prospects. Five-day week with 18 days paid leave per year initially. Salary ranges from £680 (at age 25) to £900 p.a. Commencing salary dependent on age, quals. and exp. Applicants, who must be natural born British subjects, should write to AIR MINISTRY, W.G.d., LACON HOUSE, THEOBALDS ROAD, LONDON, W.C.1, or apply to any Employment Exchange quoting Kings Cross 3745, giving age, details of training, quals., full particulars of former posts held and copies of any testimonials. Candidates selected will normally be interviewed in London and certain expenses reimbursed. G 888

UNIVERSITY OF GLASGOW
DEPARTMENT OF MECHANICAL ENGINEERING

Applications are invited for LECTURESHIPS in MECHANICAL ENGINEERING, tenable from 1st OCTOBER, 1960, or such later date as may be agreed. Salary scale: £1050 to £1850 per annum. Initial salary according to experience and qualifications. F.S.S.U. and family allowance benefits.

Applicants should be qualified in some branch of Applied Thermodynamics or Applied Mechanics (including Automatic Control) or Engineering Materials. New Laboratories and equipment provide excellent scope for teaching and research.

Applications (3 copies) should be lodged, not later than 8th August, 1960, with the undersigned, from whom further particulars may be obtained.

ROBT. T. HUTCHESON,
Secretary of University Court. C 388

THE POLYTECHNIC
309, REGENT STREET, W.1
DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING

Applications are invited for a full-time post as GRADE B TEACHER for students preparing for the B.Sc.(Eng.) and Diploma courses of equivalent standard.

The appointment will commence on 1st September, 1960, and the salary scale for a graduate rises to £1240 plus London allowance of £38 or £51 per annum, with additional allowances for training and good honours degree where applicable. The commencing salary will include increments for previous industrial and/or teaching experience.

A form of application, which should be returned by not later than 8th JULY, may be obtained from the undersigned.

J. E. RICHARDSON,
Director of Education. C 398

THE POLYTECHNIC
309, REGENT STREET, W.1
DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING

Applications are invited for a post as LECTURER, duties to begin on 1st SEPTEMBER, 1960. Candidates should be qualified both academically and by industrial experience to lecture on Civil Engineering subjects to students preparing for the B.Sc.(Eng.) and the Diploma of Technology.

The salary scale commences at £1370, rising by annual increments of £35 to a maximum of £1550, plus London allowance of £38 or £51 per annum.

A form of application, which should be returned by not later than 8th JULY, may be obtained from the undersigned.

J. E. RICHARDSON,
Director of Education. C 397

GOVERNMENT OF HONG KONG

ELECTRICAL/MECHANICAL ENGINEER

PUBLIC WORKS DEPARTMENT

Duties comprise the design, estimation, installation, operation and maintenance of air conditioning installations in large buildings including refrigeration plant.

Permanent and pensionable appointment. Salary according to experience within the range £1650-£2865. Quarters at low rent. Free passages. Generous leave.

Candidates must be under 35 years and A.M.I.E.E. OR A.M.I.Mech.E. with at least 3 years' post qualifications experience in the refrigeration industry.

Write DIRECTOR OF RECRUITMENT, COLONIAL OFFICE, LONDON, S.W.1, giving full names, age, qualifications and experience, quoting BCD 112/51/033/D5. C 384

CITY OF WORCESTER

COLLEGE OF FURTHER EDUCATION

VICTORIA INSTITUTE

Applications are invited for the post of ASSISTANT (GRADE A) in the DEPARTMENT OF ENGINEERING to teach Machine Shop Engineering subjects up to the Intermediate City and Guilds Certificate level.

Salary will be in accordance with the Burnham (Technical) Scale, i.e., £520 by £27 10s. 0d. and one final increment of £40 to £1000. Increments within the scale are payable in respect of previous teaching or approved industrial experience.

Applicants should be suitably qualified and have industrial experience. Previous teaching experience is desirable.

Application forms from the DIRECTOR OF EDUCATION, 13, HIGH STREET, WORCESTER, to be returned as soon as possible. C 395

MANCHESTER CORPORATION

WATERWORKS

Applications are invited for the undermentioned appointments in connection with the design and construction of treatment and filtration plant, and large service reservoirs, the reconstruction of existing reservoirs, and the reconditioning of main aqueduct:

ASSISTANT ENGINEERS (CLASS II)
£785/£1070
ASSISTANT ENGINEERS (CLASS III)
£610/£880

Applications stating (1) age, (2) education and training, (3) professional qualifications, (4) experience in the preparation of plans and construction of waterworks or other civil engineering works, together with the names of two referees, should be addressed to the ENGINEER AND MANAGER, WATERWORKS OFFICES, TOWN HALL, MANCHESTER 2, not later than 12th JULY, 1960. C 392

HERIOT-WATT COLLEGE, EDINBURGH

DEPARTMENT OF MECHANICAL

AND CIVIL ENGINEERING

Applications are invited for appointment as LECTURER IN MECHANICAL ENGINEERING to commence duties on 1st September, 1960, or as soon as possible thereafter. Candidates should have a University Degree in Engineering or equivalent qualification, together with industrial experience. Previous teaching experience is desirable. Duties will include the development of courses in Principles of Engineering Production and of newly equipped machine tool, metrology and heat treatment laboratories. Knowledge of production techniques is essential. Salary scale within the range £800-£1550 on which the successful candidate may be placed according to qualifications and experience.

Further particulars and form of application, which should be returned to the PRINCIPAL not later than 1st JULY, may be obtained from the College. C 389

LONDON COUNTY COUNCIL

PADDINGTON TECHNICAL COLLEGE

Required in September, 1960, for Ordinary National Certificate courses:—

TWO GRADE B ASSISTANTS to teach:—
(i) Mathematics and Engineering Science.
(ii) Workshop Technology and other Mechanical Engineering subjects.

Further particulars and application forms from COLLEGE SECRETARY (FE3a/F/1634/6), SALTRAM CRESCENT, W.9. C 396

MIDDLESEX COUNTY COUNCIL

REQUIRED IN

COUNTY ARCHITECT'S DEPARTMENT

(*a*) ENGINEERING ASSISTANTS, APT. III, £880-£1065 for preparation of drawings and specifications for heating and hot water installations.

(*b*) ENGINEERING INSPECTOR, APT. II, £765-£880 for supervision of installation of heating and hot water services in buildings in the County.

Both posts: Established; London Weighting payable up to £45.

Application forms from the COUNTY ARCHITECT, 1, QUEEN ANNE'S GATE BUILDINGS, DARTMOUTH STREET, S.W.1 (s.a.e.), returnable by 10th AUGUST. Prescribed conditions. (Quote C.815E.) C 390

APPOINTMENTS OPEN

SENIOR DESIGN ENGINEER

HYDRAULIC PRESS MANUFACTURER requires SENIOR DESIGN ENGINEER to take charge of small expanding design office. Preferment given to man with broad experience in Press design, coupled with initiative and originality.—Write giving details of age, experience and salary required to BOX C 368, Offices of ENGINEERING.

AN ARCHITECTURAL or BUILDING DRAUGHTSMAN

is required by

W. H. ALLEN SONS & COMPANY LTD.

for their

WORKS ENGINEERS DEPARTMENT

Experience of architectural and civil engineering design is necessary and it is desirable that applicants should have had some basic technical training.

The Company offers excellent conditions of service, a contributory Pension and Life Assurance Scheme and a comprehensive range of welfare and recreational amenities. Assistance will be given towards expenses involved in moving to the Bedford area, where appropriate.

Applications should be made in writing, giving details of age, past experience and present salary to:—

THE PERSONNEL MANAGER
(REF. 1604C/10)
QUEENS ENGINEERING WORKS
BEDFORD C 357

DESIGN DRAUGHTSMEN

required for Material Handling Division, experienced men preferred but not essential provided qualifications and engineering background are suitable. Pleasant working conditions and canteen facilities. Write stating age, experience and salary required to:—

THE SECRETARY,
BRITISH
JEFFREY-DIAMOND
LIMITED,
STENNARD WORKS,
WAKEFIELD

C 359

BRITISH HYDROCARBON CHEMICALS LIMITED

have vacancies for

MECHANICAL ENGINEERS

at their rapidly expanding Grangemouth Works. Preferred ages 22/28, but older fully qualified Mechanical Engineers can also be considered. Applicants must have a degree in engineering or have been accepted as graduate members of the Inst. Mechanical Engineers. Practical training can be provided where necessary towards qualifying as A.M.I.Mech.E. Salaries will be in accordance with qualifications and experience and a non-contributory pension scheme is in operation.

Replies should be addressed to the

ADMINISTRATIVE OFFICER
BRITISH HYDROCARBON
CHEMICALS LIMITED
BO'NESS ROAD
GRANGEMOUTH, STIRLINGSHIRE

C 370

UNIVERSITY OF LONDON KING'S COLLEGE

SHELL STUDENTSHIPS IN CHEMICAL ENGINEERING

Value £375 each plus tuition fees. May be held for the one year postgraduate course for the College Diploma in Chemical Engineering, or for the first year (with possible renewal) of higher degree work.

Applications are invited from graduates in Chemistry or Engineering. Forms must be obtained from the

REGISTRAR
KING'S COLLEGE
STRAND, LONDON, W.C.2,

and must reach him completed by July 4th, 1960.

C 358

MULLARD SOUTHAMPTON WORKS

have a vacancy for a

GRADUATE ENGINEER

to join their rapidly expanding Plant Department. The department services an establishment concerned with research, development and quantity production of transistors, and the post calls for a man capable of progressing to a senior appointment. A post-graduate apprenticeship or sound practical experience are therefore essential. The position offers an opportunity to extend practical knowledge in a very wide variety of engineering services within a large and expanding group of companies.

Please apply in writing to the PLANT PERSONNEL OFFICER, MULLARD SOUTHAMPTON WORKS, MILLBROOK INDUSTRIAL ESTATE, SOUTHAMPTON, quoting the reference C.14.

"Mullard" is the Trade Mark of Mullard Limited.

C 383

GKN

THE GUEST, KEEN & NETTLEFOLDS GROUP OF COMPANIES WISH TO MAKE THE FOLLOWING APPOINTMENT

HONOURS GRADUATE FOR OPERATIONAL RESEARCH

The Midlands Operational Research Unit of this Group of Companies which is based on Wolverhampton wishes to appoint a young man aged 21/27 to join a team studying management problems in the manufacturing companies of the Group. A good honours degree from a United Kingdom University is essential; the subject of the degree is of secondary importance, although some preference might be given to a Statistician or an Engineer. Industrial or operational research experience is not necessary.

Applications giving details of age and qualifications should be sent to the

RECRUITMENT OFFICER
G.K.N. GROUP RESEARCH LABORATORY
BIRMINGHAM NEW ROAD
LANESFIELD, WOLVERHAMPTON C 374

DESIGN ENGINEERS/DRAUGHTSMEN

(DEVELOPMENT)

are required to give technical assistance on plant, product and production problems within the Company's Engineering Development programme.

The responsibility of one position includes the general supervision of the work of a small team of Draughtsmen.

Candidates should be about 35 years of age with at least an O.N.C. and preferably an H.N.C. in Mechanical Engineering. Their experience should be such as to give them a working basis for approaching with confidence new and interesting engineering problems. The salary scale is attractive and the appointments are pensionable.

Please reply giving full details of age, education, qualifications and experience to:—

THE STAFF OFFICER
NEWTON, CHAMBERS & CO: LTD:
THORNCLIFFE
NEAR SHEFFIELD C 364

FIBREGLASS

RESEARCH AND DEVELOPMENT

MECHANICAL ENGINEERS

If you have a good honours degree in Mechanical Engineering and would like to hold a responsible job in an expanding industry, you are invited to write about yourself to MR. A. DE DANI, MANAGER, RESEARCH AND DEVELOPMENT, FIBREGLASS LIMITED, ST. HELENS, LANCASHIRE.

You would be given varied and interesting work on all process and product development on existing plant and design and operation of new plant and processes. Based on St. Helens, you would have occasion to visit works in Glasgow and Birkenhead.

C 346

SIMMS MOTOR & ELECTRONICS CORPORATION LTD.

require the services of a

PATENTS ENGINEER

The Applicant should preferably be a Chartered Patent Agent and should be able to deal with all aspects of patent applications in connection with the company's products which cover the field of hydraulics, electrical machines, electronics and aerodynamics. He should also be capable of dealing with legal matters associated with licensing arrangements.

Applications should be submitted to the Technical Director at:—

SIMMS MOTOR UNITS LTD.
The Grange, East Finchley, London, N.2

C 400

PRINCIPAL DESIGN ENGINEER WEST INDIES

A major oil company requires a Principal Design Engineer for its organisation in the West Indies. He will be responsible to the Chief Engineer for civil, structural, and mechanical engineering design, including pipework and pressure vessels. Applicants should have a Technical Degree which has involved study of Civil or Mechanical Engineering and would be expected to have Associate Membership of the appropriate Engineering institutions. Design Office and site training with a reputable Civil Engineering Consultant or Contractor, or else workshop experience with a mechanical engineering firm manufacturing heavy industrial machinery is required. Subsequent extensive design experience in either civil or mechanical engineering works would be expected and knowledge of the requirements of the petroleum or chemical industries would be an advantage. Preferred age 35/40, but up to 43 if immediately previous overseas service has been obtained. Initial salary about £2500 dependent on experience and qualifications; married quarters provided at low rental. Good primary and secondary schools provided. Excellent medical and sports and social facilities. Reference Number 82.

Please reply in confidence, quoting reference number, to:

Robert Clive (Consultants) Limited

Appointments Consultants

27, ALBEMARLE STREET, LONDON, W.1

C 379

GEAR DESIGNERS AND LAYOUT DRAUGHTSMEN

A modern expanding engineering organisation require gear designers and layout draughtsmen for work on an interesting range of projects including gearboxes for gas turbines and special purpose gearboxes for a variety of requirements.

Applications should have minimum technical qualifications equivalent to the Ordinary National Certificate in mechanical engineering and should be keen to work with an organisation having clearly defined aims and objectives. There is a non-contributory pension scheme and this is one of the pleasanter areas of the country in which to live.

Applicants should write to the
PERSONNEL OFFICER, quoting GD 100,
CENTRAX LIMITED, SHALDON ROAD, NEWTON ABBOT, DEVON

C 372

CONSTRUCTORS JOHN BROWN LIMITED

require a

SENIOR
ELECTRICAL ENGINEER

Applicant must be a Corporate Member of the I.E.E. with design experience in industrial electrical work and, preferably, power supply experience.

Five-day week, good salary and contributory pension scheme.

Please apply, giving full details to:—
THE PERSONNEL MANAGER
CONSTRUCTORS JOHN BROWN LIMITED
C.J.B. HOUSE
EASTBOURNE TERRACE
PADDINGTON, LONDON, W.2
quoting Ref. No. J7059

C 385

ELECTRICAL ENGINEERS

Electrical Engineers are required by one of the leading manufacturers of Iron and Steel, to assist with the electrical engineering side of a large development programme.

Candidates must have a good theoretical background and possess a degree and/or professional qualifications. Wide practical experience in manufacturing industry an advantage. Experience in iron and steel industry and particularly on Continuous Mills would be an asset.

Terms of service and other conditions are attractive and the housing situation is good. There is a Staff Pension Fund and Life Assurance Scheme.

Applications will be treated in complete confidence and should be addressed to BOX C386, Offices of ENGINEERING.

METALLURGIST

RESEARCH LABORATORIES, AUSTRALIAN POST OFFICE—MELBOURNE

DUTIES: Research into properties of metallic protective coatings, investigation of metallurgical failures, analysis of metals, etc.

QUALIFICATIONS: Science Degree, preferably with Honours or equivalent. Experience in Metallurgical Research an advantage.

SALARY: £A1235 to £A1620.

Commencing rate according to experience and qualifications.

* Permanent Appointment. * First-class passages for appointee and dependants.
* Initial accommodation arranged. * Salary from date of embarkation.

APPLICATIONS TO:—

AUSTRALIAN POST OFFICE REPRESENTATIVE, AUSTRALIA HOUSE, STRAND, LONDON, W.C.2

by 8th AUGUST, 1960.

C 356

DEVELOPMENT ENGINEER

Young, creative engineer with ability to develop and improve equipment and methods of conversion and packaging for household paper products required by the Bowater-Scott Corporation Limited. This is a new appointment, the scope of which depends on the capabilities of the successful applicant. He will not be encumbered with routine duties, but will be expected to work largely on his own initiative.

This position calls for a graduate engineer or equivalent, with previous experience in one or more of the following types of machinery:

High Speed Packaging
Printing
Paper Conversion

PREFERRED AGE: 35 years.

The Development Engineer will be directly responsible to the General Manager for work carried out at both the Northfleet, Kent, and the Walthamstow, Essex, mills. He will be based at Northfleet. Salary will be progressive and subject to an annual review.

This is a unique opportunity to join a rapidly expanding organisation and applications, in strict confidence, should be sent to the following address, stating age and full details of education, qualifications and experience:

Personnel Officer,
The Bowater Paper Corporation Limited,
Bowater House, Knightsbridge,
London, S.W.1.

C 378

RAYMOND INTERNATIONAL (U.K.) CONSTRUCTION, LTD.

require

ENGINEERS, preferably grade I.C.E. or equivalent, with 2 years' site experience for work in their London office on administration of overseas contracts. Permanent post with prospects of work overseas at a later date.—WINGATE HOUSE, 93-107 SHAFTESBURY AVENUE, W.1. Telephone: REGENT 7536.

C 367

DRAUGHTSMAN

DRAUGHTSMAN required to handle contracts on Small Water-Tube Boilers including design and detail work. EAST LONDON AREA. State age, salary and experience.—BOX C353, Offices of ENGINEERING.

ASSISTANT ENGINEER

THE BOWATER PAPER CORPORATION LIMITED invites applications for the post of ASSISTANT ENGINEER (HEATING AND VENTILATING). The duties will include the design and selection of equipment associated with Factory and Office Block heating and air conditioning and the design of special purpose ventilation plant connected with paper machinery. The applicant must have received a thorough training in heating and ventilating practice and held a responsible position for at least two years. The qualifications required are H.N.C. or A.M.I.H.V.E. Applications in writing stating salary required should be addressed to THE CHIEF ENGINEER, THE BOWATER PAPER CORPORATION LIMITED, ENGINEERING DIVISION, NORTHFLEET, KENT.

C 328

ASSISTANT ENGINEER

BRITISH MANAGED PULP AND PAPER MILL in India requires ASSISTANT ENGINEER not over 40 years of age. Progressive position with prospects of further promotion for an applicant with experience in maintaining modern Fourdrinier Paper Machines and auxiliaries, Pulp Preparation Plant, Power Plant, etc. Good salary offered with leave on full pay and free passages, free quarters, medical attention and membership of superannuation and Provident Funds.—Please reply to BOX NO. 3448, c/o CHARLES BARKER & SONS LIMITED, GATEWAY HOUSE, LONDON, E.C.4.

C 272

ENGINEERING DESIGN

TECHNICIAN for work on engineering design and vibration/shock calculations required by expanding concern in East Midlands. Graduates who are interested in the scientific approach to engineering should give details of education, previous experience and present position.—BOX C 377, Offices of ENGINEERING.

DEPUTY CHIEF OF PLANT

SÃO PAULO LIGHT S.A.—SERVIÇOS DE ELETRICIDADE, a Company in Brazil and a subsidiary of the Canadian corporation Brazilian Traction, Light and Power Company Limited, invite applications from suitably qualified men for the position of DEPUTY CHIEF of its PIRATININGA POWER STATION. The power station was completed about five years ago and is situated near São Paulo (population over 3 millions; temperate climate, 2,200 ft. above sea level). The plant comprised initially 2 × 100 MW., 1,800 r.p.m. steam turbo-generator units each supplied at 850 p.s.i., 900 deg. C. by one 850,000 lb./hr. oil fired boiler and has been recently expanded by the addition of two 125 MW. reheat units, 1,800 p.s.i., 1,000 deg. F. Applicants should have sound technical knowledge and good practical experience in the administration, operation and maintenance of steam-electric power stations; should also be of strong character with an aptitude for supervision and the maintenance of harmonious labour relations. Good salary, three years' agreement with first class passage both ways; four months paid leave after three years service.—Written application in the first instance should be made to MR. OSBORNE MITCHELL, GENERAL MANAGER, CANADIAN-BRAZILIAN SERVICES LIMITED, 9/12, CHEAPSIDE, LONDON, E.C.2.

C329

COMPANY MEETING

WORTHINGTON-SIMPSON LTD.

Encouraging Prospects

The 69th annual general meeting of Worthington-Simpson Ltd. was held on June 23 in London, SIR SAMUEL R. BEALE, K.B.E., M.I.Mech.E. (Chairman of the company), presiding.

The following is an extract from the chairman's circulated statement for the year 1959:—

It gives me much pleasure to present to you the results of another year's satisfactory operations. I say satisfactory notwithstanding a drop of £163,428 in the Trading Profit to £1,018,246 compared with last year's figure of £1,181,674. After full provision for all charges, including taxation, a net profit of £476,051 is shown, against £543,759 for 1958.

The decline in profits is not so great as was anticipated due mainly to a marked increase in the sales of our standard products. During 1959 we both sold and produced more of our standard ranges of equipment than ever before and so far this year the trend continues as a result of which our order book remains at its usual high level.

We have, on the heavy plant side of our activities, obtained two most valuable contracts from the Central Electricity Generating Board for condensing and feed-heating equipment for Bankside Power Station, London, and condensing plant for West Thurrock Power Station, Essex.

Prospects for 1960 are encouraging, particularly as fairly substantial shipments of equipment for the £2 million contract for the new power station at Buenos Aires will be made during the course of the year.

In view of these prospects, your Board feels a slightly higher distribution of profits is justified and accordingly recommends that the final dividend on the Ordinary Capital be 12½ per cent, less tax, making a total of 20 per cent, less tax, for the year.

The report and accounts were adopted.

C 355

FOR ADVERTISEMENT RATES: SEE TRADE & TECHNICAL SECTION PAGE 3.

Companies

Taking the Top Off the Boom

THE effect of the April hire-purchase tightening up has worked its way through to the point where HOOVER, the largest United Kingdom company solely devoted to producing domestic appliances, is dismissing 800 people, a tenth of those employed by the company.

In the export field Hoover sales are reported by the company to be substantially higher than a year ago but the lower level of home demand, and hence of production, must have some effect here. If the fall in home sales goes on then higher production costs will follow and Hoover appliances will be that much limited in their competitive power abroad.

Washing machines in particular have become a fiercely competitive affair, both at home and overseas. They are not the only section hit by the hire purchase changes. Vacuum cleaners, electric irons and floor polishers have all suffered.

If this is the picture for appliances whose appeal is not tied to any special season, what is happening to refrigerators? Their sales are stated by the retailers to be more or less steady. This is equally a disappointment, for the refrigerator idea is generally believed to be at last catching on in Britain and by this period of the summer a vigorous demand might have been in full swing.

As it is many shops can be seen along the High Streets bulging with gleaming refrigerators that decline to move.

The dismissals from Hoover plants will be evenly spread through skilled, semi-skilled and unskilled workers at the three factories—Perivale, Middlesex; Merthyr Tydfil, Glamorganshire; and Cambuslang, Lanarkshire.

Vauxhall Growth Plans Meet Opposition

Other manufacturers, the local ratepayers' society, the Council for the Preservation of Rural England, and the Manchester Ship Canal are among the objectors to VAUXHALL MOTORS' proposals for a commercial vehicle factory on a former airfield at Hooton Park, in the Wirral, in the North West.

Presumably among the implicit supporters of Vauxhall's scheme are the unemployed of Liverpool and Birkenhead and the Board of Trade who persuaded the company not to extend at Luton but to set up their new capacity in an area of high unemployment.

The case has been before an inquiry for the Minister of Housing at Chester. For Vauxhall it was said that they would like to use 400 of the airfield's 500 acres, which lie alongside the Ship Canal. The Cheshire County Council, who are the planning authority and the local councils have general reservations but are not objecting in principle.

Vauxhall would, of course, have liked to expand their thriving Bedfordshire plant where not so long ago they were bulldozing away much of a large hill in order to make a multi-million pound extension.

Instead, they will be following, when the location in the North West is decided, in the footsteps of their motor company colleagues. Production of private cars at Luton will become more concentrated. Vehicles for commercial use will become equally concentrated, perhaps at Hooton.

Progress and Products in Asbestos-Cement

At first sight the asbestos-cement slurry rushing turbulently through underfloor channels and the pairs of men removing the newly pressed corrugated sheets from the machines by hand give the great 49 acre Widnes factory of the Turner & Newall organisation an air of being engaged with the forces of nature.

Closer examination reveals just how far the same forces have been channelled by the judicious application of mechanisation at key points. From a recent tour of the works a random recollection is to the point.

Every single pressure pipe formed and machined in the works is carefully pressure tested before being released. In one of the necessarily roomy bays of the works two women roll the pipes towards a trough where the testing is to be carried out with water. It looks as if the two women have a hefty problem on their hands.

But in fact, in one of the women's hands is the control for the overhead crane. At the press of a button the crane swings aloft the pipe, lowers it into the trough, and after testing hauls it out again while one woman tips the end down to run the water out.

Colourful and vivid are the stories of the old timers who used to put a set number of sacks of cement and asbestos into the machines. A primtive form of process control. Now the Widnes factory has six towering 500 ton cement silos. The cement is brought to the silos in pressurised rail containers and then pumped in.

This has immensely improved working conditions, increased the degree of process control and reduced costs.

For the executives of the Widnes factory the happiness of their labour relations is an object of as much pride as the quality and demand for their products. There are strong family connections running through the departments that help to explain the cooperative atmosphere.

Another factor may lie partly hidden in the nature of some of the processes. This is a plant where the men, only 1,600 in almost 50 acres, are very much in command of the machines, and not the other way about.

Nobody can quite remember the last strike. It was generally thought to be "somewhere in the 1920's."

Almost 300 of the workers have been at the factory for more than 25 years, over 800 have more than 10 years service, and a select band of 11 have been there for more than 40 years.

At the moment, just as the company has all the orders it can handle—Mr. J. P. McCormick, the Widnes works director, told ENGINEERING he saw the present full blast conditions going on well into 1962—so it has no problem in getting the workers it wants.

How will the advent of the motor firms, and their accessory manufacturers to the North-West affect the company? Its wage rates are not at the moment those paid to workers in the car firms.

In fact the company has strong advantages. Its employment does not fluctuate. When demand was less strong two years ago batches of men were not laid off, instead the whole production complex simply ran rather slower.

The arrival of the motor firms will have an effect not yet discernible, though the company is watching the point closely.

One thing is certain. The long continued policy of ploughing back the profits has raised the Turner & Newall group to the position where the capital issued is some £23 million, and the capital employed in the business, £75 million, is more than three times greater.

If further steps in mechanisation or re-equipping are needed, the group is in an excellent position to take them.

Ampex Start Basic Research in Britain

The British subsidiary of the international AMPEX electronics company is to establish a basic research centre. Mr. Eric Daniel (*inset*) who has a reputation in this country and abroad for his

work on magnetic tape recording, will lead the new unit, which is being set up at Reading, Berkshire, the location of AMPEX ELECTRONICS Limited, the UK concern.

Dr. Peter Axon, managing director of Ampex in Britain, has said that the research programme will be coordinated with that of the Ampex corporate research division at Redwood City, California. There a wide programme was going on with new methods with memory devices for recording sound, sight and coded impulses.

Mr. Daniel, after taking a Master's degree in physics at Oxford, worked in the research teams of the Post Office and the BBC and served for three years with the United States Bureau of Standards in Washington. For the past year he has been at Redwood working on the performance characteristics of materials used in making magnetic tape.

In addition to his papers on fundamental aspects of magnetic tape recording, Mr. Daniel holds a number of patents in this work. Some of the research work of his team at Reading will be breaking new ground for the corporate Ampex programme.

Output to Fall at BMC and Vauxhall

Shortages of both steel and labour are partly the cause of the run down in the production schedules of the M.G. and Sprite cars of the BRITISH MOTOR CORPORATION and in VAUXHALL cars.

The Vauxhall company has explained that there will be some reduction in car output, by about a hundred a week, as the result of temporarily ceasing Saturday morning work by some 3,000 workers. The company has stated that there is now a fairly widespread shortage of components in the industry. Vauxhall is feeling it most in castings, forgings and such contributed components as door handles.

The normal seasonal drop and and increasing competition in the United States' market from compact cars have produced a slight falling off in demand. In Canada, where the Vauxhall Victor has turned out to be the most popular British car, sales are giving no cause for concern.

For BMC it has been said that the reduction in MG and Riley output is seasonal and will be met by redeployment of workers and not by dismissals. Calculations of the supply of sports cars in the supply lines and the wish to avoid more sharp alterations in working in the winter are apparently the principal reason for the BMC changes. Output of the MGA sports car and the Sprite will fall by about 250 a week—to a level still above 1,000 each week.

Elliott Well Placed for Double Expansion

Throughout the United Kingdom and Western Europe the most serious limitation to increasing industrial production is the difficulty of finding sufficient suitable labour.

At the same time the big economic groupings, the European Common Market and to some extent the European Free Trade Area, are going to make mass production at once more profitable and more necessary. From all this one of the companies best placed to benefit is ELLIOTT-AUTOMATION Limited.

Its recent annual report shows that at the research and development centre at Borehamwood, in Hertfordshire, the company employs 1,700 people. In addition to its own power to attract some of the best engineers in electronics to its team, Elliott-Automation has agreements with the United States' NATIONAL CASH REGISTER Company, and with the French concern, MANUFACTURE DE MACHINES DE HAUT-RHIN (MANHURIN). Equally well placed to share in European industrial advance is the subsidiary, ELLIOTT-AUTOMATION AG, formed in Switzerland two years ago and now engaged on a contract for the full instrumentation of a refinery.

Other subsidiary companies have been set up in Western Germany, the Netherlands and in Australia.

The net profit for the group last year reached, for the first time, just over £1 million. After tax this amounted to £548,875, compared with the 1958 figure of £458,628, which included Associated Insulated Products, since disposed of. The growth of the group is best illustrated by the addition to the organisation each year for some time past of five or six divisions. These now extend from Aircraft Instruments Service to Vacuum Physics Research.

The high vacuum field and specialised vacuum equipment and electronic valves has seen the successful launching of one new division. Another is concerned with the expanding quality control instrument sector with its mass spectrometers and moisture monitors.

Elliott-Automation is by no means over-dependent on defence contracts, but it is responsible for the guidance system on the guided bomb Blue Steel.

Broaching Can Be Put to Better Use

It has been said that broaching can be utilised to machine any surface, regular or irregular, internal or external, provided only that the broach encounters no obstruction in the path parallel to its axis. The truth of this statement is now being recognised.

By M. Jellis, Group Chief Engineer

Coventry Gauge and Tool Company Limited

FORTY years ago, broaching was mainly confined to work which could not be produced economically by the more conventional methods, such as slotting. Now, apart from its unassailable position in the economical production of keyways, splines and serrations, and internal bores of other shapes, it is invading the realms of machining processes previously dominated by shaping and milling machines, and to some extent, the planer. Recent development indicate, moreover, that gear production may well be in its scope. This position has, to a great extent, been brought about by the long production runs required by industry, particularly in the automobile and ancillary industries. Here production runs with absolute reliability of the accuracy of the work produced, are essential, together with consistent quality, irrespective of the skill of the operator.

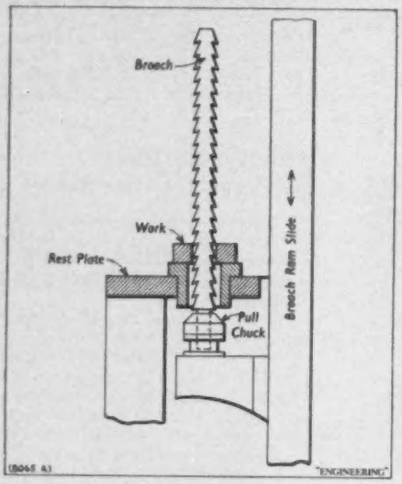


Fig. 1 Pull down broaching.

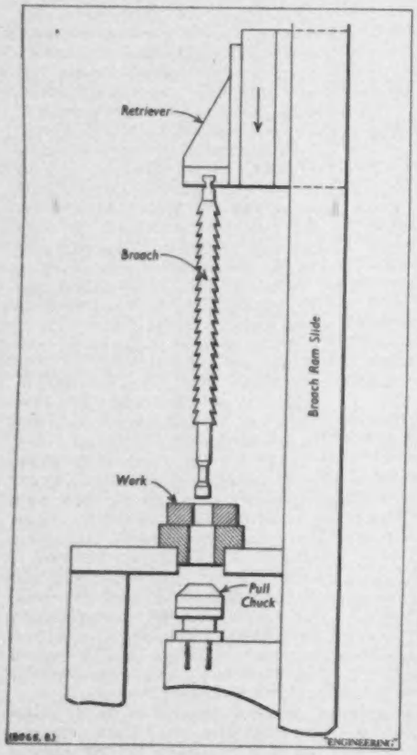


Fig. 2 The addition of a retriever.

SIMPLICITY

Basically, the broaching machine is very simple. It has slow moving parts giving long life, with the minimum of maintenance required to give consistently good results. Furthermore, due to the relatively slow cutting speed, long life of the broach can be expected with the minimum of down time for resharpening.

It is the general practice to have two or three sets of broaches so that a spare set can be always reground and brought into commission as soon as required after predetermined numbers of components have been broached. This renders the reliability of the process such that the production engineer has full confidence that the quality of the work will be fully restored with the minimum of down time before the machine is again in full production.

The design of broaches has now become such a science that the quantity, life and quality of the component for any given material, can be accurately predicted. In addition, the quality of the work produced will not measurably deteriorate due to ageing of the machine, such as is experienced on other types of machine tools.

The broaching process with the modern vertical machine is easily set up for short run work, and has now been developed for large production runs where fully automatic set-ups are required to run in line production. In the former circumstances, the broach and the work is handled by the operator, and there are various stages in between this and the latter method where the machine is magazine fed and is fully automatic and requires no attention except for the changing of the broaches after a predetermined number of components have been broached.

There are four general methods of tooling up the vertical broaching machine, which is more popular than the horizontal machine, due to versatility and reduction of floor space required. These are:

1. Pull down broaching
2. Push down broaching
3. Pull up broaching
4. Surface broaching

It will be as well to examine these four basic methods so that a full appreciation of why a particular method is adopted can be seen, and also to appreciate the variations that can be achieved with these four basic principles.

PULL DOWN

Common pull down broaching is illustrated in Fig. 1. The broach slide, which is usually moved by hydraulic means, is bolted to a pull block and pull chuck. The broach is inserted through the component and pushed into the pull chuck. Then, operation of the machine causes the broaching ram to pull the broach through the component, which is removed. The broach slide then returns to its starting position, when the broach is removed and inserted through another component and the process repeated.

To save arduous handling of the broaches by the operator when large broaches or more than one broach is being used simultaneously, it is usual to provide a retriever unit, as shown in Fig. 2. This picks up the broach and lifts it clear of the work rest plate so that the component or components can be placed in position, after which the retriever lowers the broach into the pull chuck and the process is repeated as before. This retriever unit is especially beneficial when two or more broaches are being used.

A simple variation of the above process is push broaching which is quite convenient for

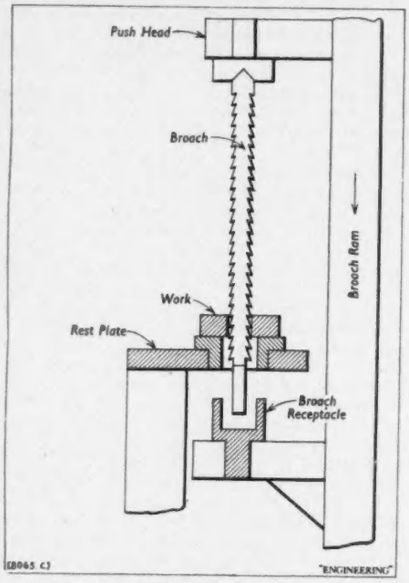


Fig. 3 Push broaching.

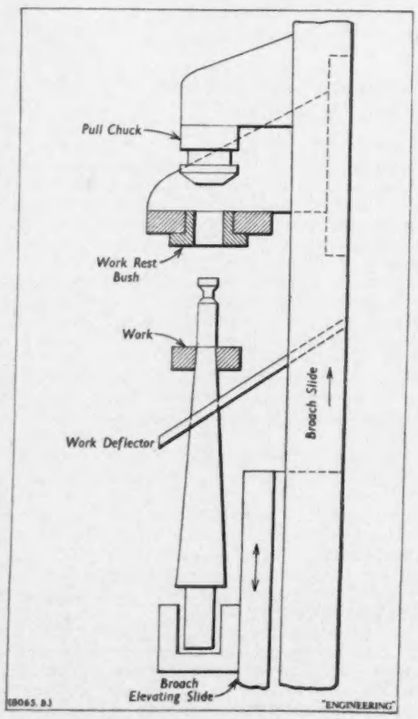


Fig. 4 A method of pull-up operation.

short broaches which are relatively stiff. Fig. 3 clearly shows this method where the broach is pushed through the component to fall into a receptacle on the broach ram. After the work has been removed it can be returned and lifted out by the operator to allow a new workpiece to be inserted: a quick and cheap process for such work as hole sizing and burnishing.

Pull broaching is usually employed where the component has to be located in a fixture and therefore has to be readily accessible by the operator, but for some simple components where rapid production is required, it does have the disadvantage that the chips caused by broaching fall on to the work rest plate, and have to be cleared before a new component is placed in position. Also, if the broaching has to be carried out in two operations, it is necessary to locate the broach and component in the right position for the second operation.

Fig. 4 shows how some of these disadvantages may be overcome. It is particularly useful for simple symmetrical components such as gears and bushes. In this method of pull-up broaching, the process of pull-down broaching is reversed. It will be seen that the broach rests in a receptacle on an elevating slide and the workpiece is placed upon the broach and can thus be located if it has been pre-roughed with the teeth of the previous broach. In operation, the broach elevating slide lifts the broach through the work rest bush into the pull chuck. The main broach slide then draws the broach through the component, which falls clear, strikes the deflector plate and drops into an appropriate work bin. The broach is then returned and a new component placed in position and the process repeated.

Two components can be placed on to each broach simultaneously in this method without taking much time for location and there is also no necessity for keeping chips off the work-rest plate, as they all fall clear of the working parts of the machine into a chip and coolant pan below.

More and more surface broaching is now being carried out. Fig. 5 shows the basic principle in which the work is clamped securely to the fixture, while the broach, in a holder, passes down the face to be broached. After the work is removed, the broach is returned and the process repeated.

There are a variety of methods based on this simple process, and the work may either be manually clamped into the fixture or it can be hydraulically clamped. Alternatively, it is sometimes of advantage to have a retractable table so that the machine can be made more automatic. In this case, the work is clamped on to the retractable table and, on starting up the cycle of the machine, the table advances and is automatically located into the broaching position; the broach descends, broaching the component. On completion, the work table retracts and the broach returns to its starting position, and while it is doing the latter, the operator can be unloading and loading a new component.

Fig. 6 shows a further development of this principle in which a massive bridge surrounds the broach slide and has hydraulic cylinders built into it to provide the clamping power for holding the work. This simplifies the operation as the operator merely has to load and unload the fixture. On depression of the cycle-start button, the retractable table advances to the broach position, and the clamps come down and secure the component, which is then broached. The clamps then withdraw, the table retracts and the component or components are taken out and replaced for the next cycle.

In all machines of this type, adequate safety interlocks are provided to ensure that no possible mistakes made by the operator can damage the machine or the broach. This is a most important factor, as a repetitive task of this nature can easily induce carelessness by the operator.

A magazine feeding set-up is shown in principle in Fig. 7, in which will be seen a stack of components, the transfer slide which takes the components to the broaching position, and at right angles to this, the ejector slide which ejects the component on completion of broaching.

In this type of set-up the magazine can be fed from a vibratory hopper or similar type of device. This introduces, however, the disadvantage that work which has to be accurately located or registered on a diameter or has a boss projecting beyond the location face cannot easily be ejected. Furthermore, broaching chips and swarf are liable to cause difficulties except in the most simple applications and, reverting to the other process of pull-up broaching, it will be seen that the system shown in Fig. 8 has distinct advantages.

Here again we have a magazine and transfer slide, but there is no ejector slide as the components fall off the end of the broach; neither is there any difficulty in the way of chips and coolant getting into the working parts of the machine, as these are all situated above the broaching station.

There are many variations of these ideas such as indexing fixtures, where the component is loaded at the front while broaching is proceeding; the fixture indexing at each cycle to eject and allow another component to be loaded. Again, this type of fixture can be, in many cases, magazine fed and automatically ejected.

HORIZONTAL BROACHING

Very large horizontal broaching machines have been built for broaching the surfaces of cylinder blocks, exhaust manifolds and similar large surface components, and these use broaches in which the teeth are separate inserted carbide tool bits. Very high working speeds have been achieved which have easily outstripped conventional methods of metal removing such as milling.

Other special types of work which could not be produced economically by any other method are internal spiral splined holes in which the work or broach is rotated in accordance with the required lead on the work.

Work has recently been done on the broaching of spur and spiral gears by using an internal broach so that all teeth of the gear are simultaneously produced. For many years, short lengths of gear racks have been produced by broaching but the day is probably not far away when gears will be broached, the precision, consistency and rapidity being an attractive proposition.

As stated in the opening paragraphs, practically any surface can be broached providing there is no obstruction to the broach. This is true provided that the component is strong enough to resist the force of broaching and that it is clamped securely enough to ensure that it does not move while it is being broached—otherwise satisfactory results cannot be achieved.

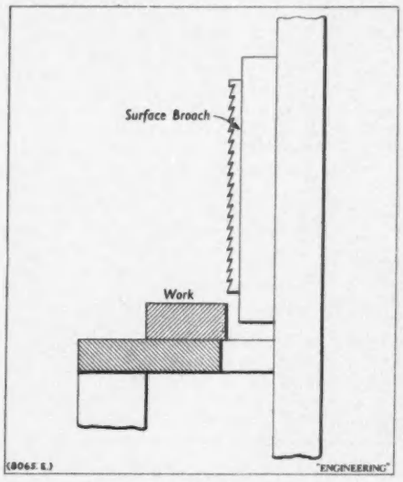


Fig. 5 Surface broaching.

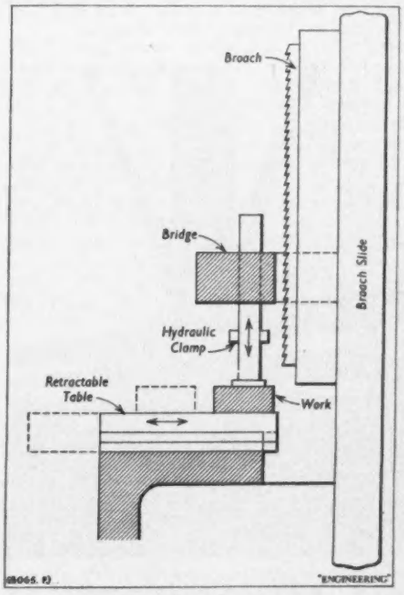


Fig. 6 Hydraulic clamping.

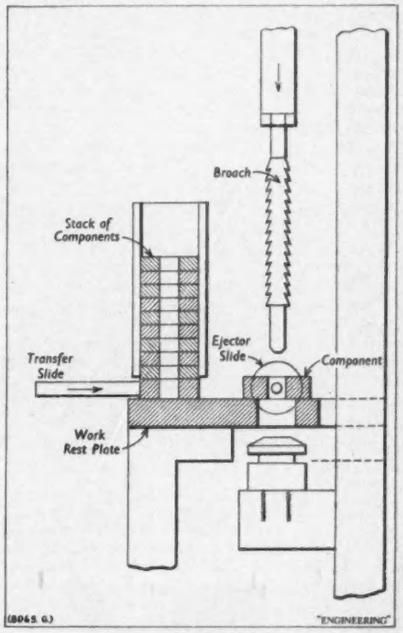


Fig. 7 Magazine feeding.

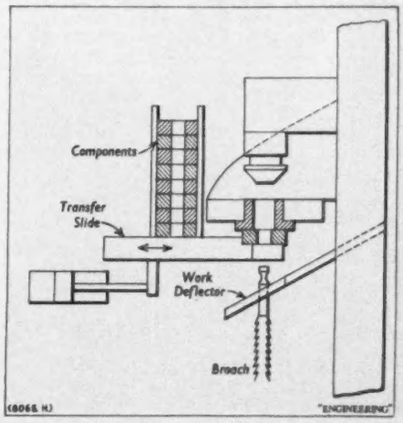


Fig. 8 Pull-up broaching using this method has distinct advantages of better chip clearance

Strengthening the Royal Albert Bridge

During repairs to the 100-year old Royal Albert Bridge, linking Devon and Cornwall, the opportunity was taken to improve certain details and to give better accessibility for maintenance.

By P. S. A. Berridge, M.B.E., M.I.C.E.

British Railways (Western Region)

THE design and erection of the Royal Albert Bridge, Brunel's last and most impressive bridge, were described in an article on his bridge engineering at the time of last year's centenary of the opening (ENGNG., 24 April '59, p. 538). Each of the two 455 ft spans is really a continuation of the original design for the half-through type plate girder approach spans, but slung beneath two pairs of suspension chains connected at the ends to an arched tubular strut.

The curvature of the chains downwards and of the struts upwards are parabolic and equal, which makes this bridge so much more pleasing on the eye than Brunel's 300 ft span at Chepstow. Each pair of chains is intended to be kept to the designed curvature by eleven verticals riveted at the top to the struts, and wedged against the links of the chains at the bottom. In turn, these verticals are kept plumb by pin-jointed diagonal flats hanging from the struts, and tightened by cotters at their points of intersection. Further restraint was provided by flats riveted to the sides of the verticals and to the stiffeners on the track girders.

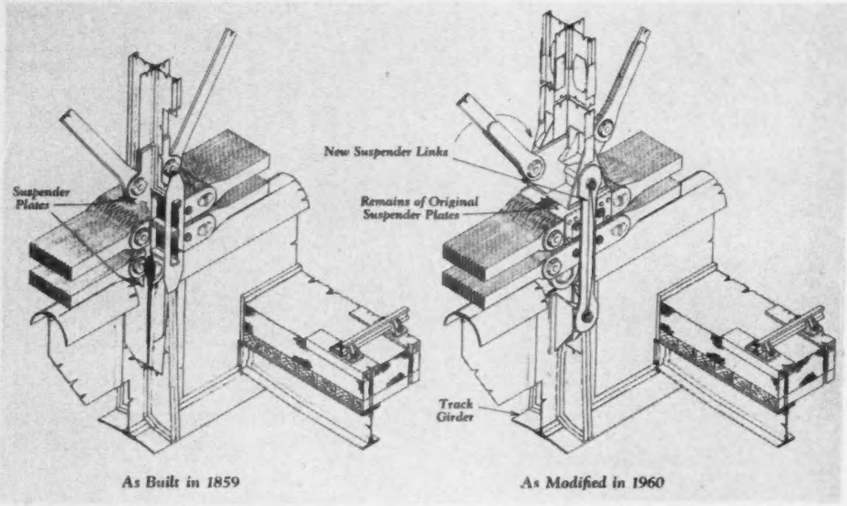
FRACTURED LINKS

This trussing, however, has not prevented the chains from moving out of their pre-set parabolic forms: the diagonals, 7 in × 1 in bars more than 25 ft in length and pinned or cottered at the ends are, of course, very flexible. They have, over a hundred years, suffered considerable wear at the joints and there has been considerable longitudinal movement of the chains relative to the truss girders during the passage of trains. This movement, amounting to $\frac{1}{4}$ in at the centre of each span, has resulted in the fracture of the suspender links and some of the outside riveted covers at the centre of the Devon span. At the other points of support where the suspender links and the verticals are longer between the chains and the track girders, there is a greater degree of flexibility and trouble is not likely to occur there. Also, the centre verticals have shown signs of overstrain about the bottom three feet above the wedges, the angles and web plates having cracked. This has been taken care of with yokes placed temporarily over the chains and under the track girders on each side of the central suspender plates.

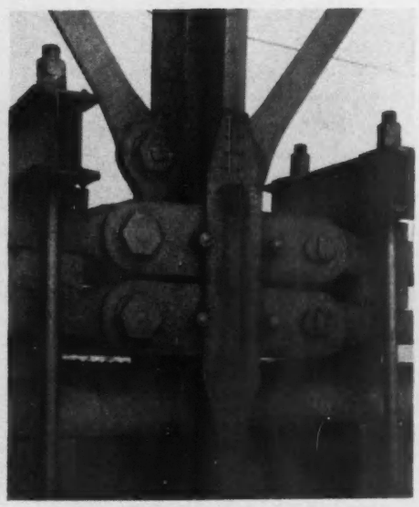
Permanent repairs have now been completed. Originally, the trusses had been assembled together with the track girders, flooring, etc., while the whole was supported on timber trestling on the Devon shore. It seems probable that the chains were assembled on this false work before being forced down and tightened by the effect of driving the steel wedges between the links and the verticals at each nodal point. The diagonals would have been in position before these wedges were driven home and, no doubt after the chains had been made to take up the required curve, the final operation would have been the driving of the cotters in the diagonals at their points of intersection.

It has been estimated that the amount of compressive force put into the central verticals by the wedging down of the chains and the tightening of the diagonals would have been about 20 tons. The small plates locating the wedges outside the chains were added after the spans had been erected; and it is to be noted that the rigid riveting of these plates to the verticals (above the chains) and to the stiffeners on the track girders prevented the free rotation of the track girders about the pins connecting them to the suspender plates. These locating plates were only $\frac{1}{4}$ in thick, and it is perhaps not surprising that fractures took place.

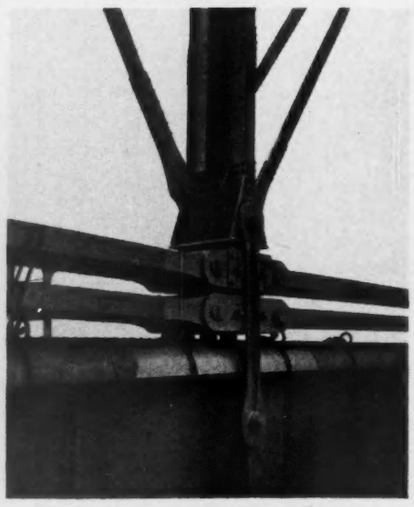
The verticals are cruciform in section, mainly of $\frac{1}{4}$ in thickness. In repairing the central suspenders it was decided to renew at the same time, completely, the bottom 6 ft of the verticals, including the eye-plate connections and some 4 ft of each adjoining diagonal. The new mild steel work includes saddles with bearing blocks resting directly on the links of the upper chains and sited in the same positions as those previously occupied by the wedges. These saddles carry stub pins from which the new suspender links (now located outside the chains) hang and connect to stub pin brackets secured to the webs of the track girders with high strength bolts. Immediately above the saddles the new sections of the verticals have been introduced, making at the upper ends joints with the wrought iron verticals, and at the lower ends joints with the saddles. Both these joints are made with cover plates secured with high strength friction grip bolts. The new sections of the verticals introducing the two joints were designed to give some freedom for aligning the new steelwork with the old wrought iron, it being appreciated that the verticals were not originally in true alignment with the chains. The new sections carried jacking brackets through which a compressive force of 20 tons was introduced into each vertical before the high strength bolts in the lower splice were fully tightened up. Four 50 ton Hydralite jacks with screwed rams were used at each vertical, and hydraulic capsules were introduced to check the load from each jack, the small load of 5 tons being too low in the scale of the pressure gauges on the jacks to give the required accuracy. The effect of introducing this prestress load at each vertical was to push down the chains and ensure that the live load reaction from the track



The old (left) and the new (right) suspender details on the Royal Albert Bridge.



On the original connection, iron wedges and window plates were used.

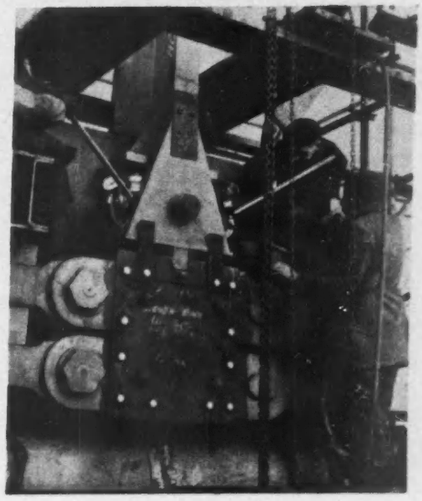


The new connection is mechanically better and gives easier access for maintenance.

girders would be shared in the correct proportions by the chains and the tubes.

The new suspender links are outside the chains and they are fitted with phosphor bronze bushes bearing on the pins on the saddle and the stub-axle pins on the brackets. The high strength bolts pass through the brackets and the webs of the track girders. Drilling the holes for these bolts was, of course, carried out after the connections between the saddles and the verticals had been completed. The final operation carried out after the tightening of the diagonals (accomplished with the aid of a special cotter and yoke bolts ensuring a pull of 5 tons in each diagonal) was the fillet welding of the edges of mild steel plates, resting on the tops of the upper chain and rammed hard against the bearing block under the saddles, to new side plates secured by stainless steel set screws tapped into the outer pairs of links in the chains. This arrangement prevents any movement of the saddle on the links of the upper chains; Brunel's wedges between the upper and lower chains still remain undisturbed, and since the suspender plates at the adjacent nodal points are pinned to both chains there is no likelihood of relative movement taking place between the upper and lower chains under the central verticals. The new suspender links, however, provide for complete freedom of rotation of the continuous track girders which can now move freely about their points of support at the centre of each truss span.

These improvements were designed under the instructions of Mr. M. G. R. Smith, M.B.E., M.I.C.E., the Chief Civil Engineer of the Western Region of British Railways. The new steelwork was fabricated by the Fairfield Shipbuilding and Engineering Company Limited, Chepstow, Monmouthshire, and the whole of the site work, completed well within four 16-hour Sunday occupations during February and March, 1960, was carried out by direct labour under Mr. N. S. Cox, M.I.C.E., District Engineer, Plymouth. In spite of this task being carried out during the winter months, it was fortunate that no rain fell during the work.



Applying the jacking load between the saddle bearing on the chain and the vertical.

Progress in Gasification of Low Grade Coal

Included in the visits made by the Institution of Gas Engineers at their recent annual general meeting at Edinburgh was one to the high pressure coal gasification works at Westfield, Fife. This plant, now nearing completion, was described in a paper read at the meeting by Mr. T. S. Ricketts, chief engineer, Scottish Gas Board; the following is derived from his paper.

Westfield works, which is designed for complete gasification of low-rank coal by the Lurgi process, is the first commercial plant of its type in Great Britain and is not only unusual in its basic principles, but also has some individual items of plant of distinctive design. The Lurgi process was chosen because it was technically proven and had particular economic advantages for the area. Most Scottish coals produce, when gasified, a moderate amount of coke and considerable quantities of breeze, neither of which offers a very good financial return. By using the Lurgi process, low-rank coal is gasified completely, and the gas, after purification, passes directly into a high-pressure grid at 250 lb per sq. in. Suitable non-caking coal will come from an adjacent opencast mine. It is expected that the works, for which Humphreys and Glasgow Limited are the main contractors and consultants, will begin making gas this autumn.

In a Lurgi plant the coal is gasified in a water-jacketted vessel, the jacket generating steam which is used to cool the mechanical grate at the bottom of the vessel and then passes into the fuel bed to take part in the gasification reaction. Coal is charged through a lock at the top of the vessel and ash is drawn off through a lock at the bottom. Steam and oxygen are blown in at the bottom and gas leaves at the top at a temperature of 400 to 450° C to enter a waste heat boiler. Besides the four Lurgi gasifiers, the plant has gas purification equipment of unusual design, and will not be equipped with gasholders. All the gas—up to 30 million cu. ft per day—will pass directly through the station meter into the high pressure grid.

Other features which are unusual in gasworks practice include three boilers each of 450,000 lb per hour capacity at 450 lb per sq. in, and a bulk oxygen plant. Lurgi gasification demands large quantities of high pressure steam and to meet this requirement Babcock and Wilcox boilers are installed. They are designed to burn fine coal of high ash content, and to be fired on gas as an alternative. To deal with the fine coal fluidised grates are fitted.

For Lurgi gasification large quantities of oxygen are also needed—Westfield will consume more than 190 tons per day at a pressure of 29 atmospheres when on full load. For this reason the works have the first tonnage oxygen plant to be installed in a British gasworks. The oxygen plant, designed and built by British Oxygen Linde Limited, operates on the liquid pump principle, separating air by fractionation and rectification into its components oxygen and nitrogen. The latter gas will be used for diluting the town gas before it leaves the works.

Discharge of purification plant gases, together with boiler flue gases, presented a chimney stack problem. The solution is a reinforced concrete shell, 275 ft high, containing three brick shafts. Ventilation holes in the concrete, together with access floors, make it possible for any one of the brick shafts to be taken out of use for inspection or repair while the others remain in service.

Water Recovery in a Steel Mill

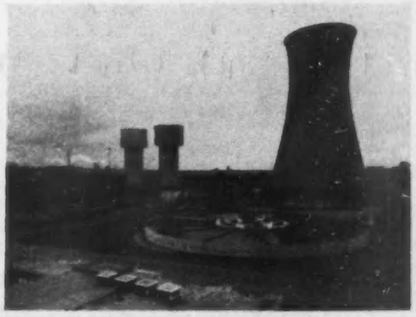
The Abbey Works of the Steel Company of Wales, one of the world's largest steelworks, with an output of approximately 3,000,000 tons a year of steel, and it is essential to recover as much as possible of discharged water for re-use.

In modern strip mills the quality of the water must be good, for otherwise rolls will not last and minute indentations will be made on the steel strip which affect the quality of the finished work. Thus treatment plant for water recovery has to be carefully designed to meet this problem and to ensure that at all times the water quality desired is maintained. The Paterson water treatment plant installed at SCoW successfully treats the effluent from the hot strip mill containing a large quantity of heavy suspended matter and oil, reducing the oil to a negligible quantity and the suspended solids to an average of 14 ppm, and even 5 ppm, without filtration.

The hot returned effluent is pumped from the scale pits direct to a primary sedimentation tank which is divided into six "canals" each about 100 ft long by 15 ft wide equipped with electrically driven chain-operated flights or scrapers, the upper flights assisting in the movement of the rising oil to the skimmers and the lower scrapers lifting the heavy suspended solids up to a sloping wall to the top of the primary clarifiers, to be deposited on an endless belt discharging by chute to a railway truck for disposal. The oil skimmers, six in number, are adjustable according to the amount of oil contained in the water and discharge into a holding tank from whence the oil can be pumped away or removed by mobile tanker.

The effluent then passes through a venturi flume where the flow is measured before it proceeds to secondary circular clarifiers of the Centrifloc type, each 130 ft in diameter. The venturi flume is also used to control automatically the coagulants which are added to the water to assist in the precipitation of the lighter and colloidal impurities. The coagulants are brought by mobile tanker to the chemical house and discharged into holding tanks from whence they are pumped to the automatic measuring equipment. Waste products are used for the coagulents, so keeping the cost of the treatment to a minimum.

The Centrifloc clarifiers are of the vertical flow type employing a modified sludge blanket with continuous sludge discharge. Their design is such as to ensure effective mixing and flocculation of the effluent before it is collected evenly over the upper surface of the clarifiers through radial launders equipped with hydraulically spaced orifices. Each clarifier has a mechanical mixer, mechanical flocculators, and sludge scrapers to remove the deposits formed on the floor of the tank, all the equipment being operated electrically. The design of the Centrifloc clarifier is such that the slurry discharge is kept down and is as concentrated as is possible.



The water clarification plant at Steel Company of Wales. The effluent is heavily contaminated before treatment but solid suspensions are reduced to 14 parts per million without filtering.

The plant was originally designed for a flow of 18,500 gpm but on completion it was found necessary to impose on the plant an overload of about 30 per cent, so that the final flow through the plant is now about 25,000 gpm.

On the Shelf

By Frank H. Smith

SOLILOQUY. I wonder if we parents and other elders are too intolerant of our children's little ways? One item for which I am prepared to beat the living daylights out of my youngest is his use and abuse of a current catchphrase. Yet I recently have noticed on a much higher plane (degree men and all that) a positive flogging of the word "this." At a conference you get so much of "This is something we must watch" and "Of course this is something we did not bargain for" and "This is, of course, the crux of the whole matter." Perhaps you, dear reader, have not noticed it but from now on you will and I hope it irritates you. *This* is something you must guard against. Oh yes, definitely.

From time to time I am prepared to admit there are other parts to this journal than On the Shelf. I am forced to do so by the appearance of a booklet called *Mechanical and Hydraulic Drives*—subtitle "Industrial uses of gearboxes fluid couplings and torque converters" (fill in your own commas). It is a booklet (25 pages with diagrams) prepared by ENGINEERING Information Service on behalf of Self-Changing Gears Limited (of Lythalls Lane, Coventry—Coventry 89081) and divided into four sections—Introduction; Description of the various types of drive; Potential industrial applications; and Illustrated technical descriptions of typical units. The booklet is gratis from Coventry. It is ideal for a design library—personal or general.

You may remember the near-international incident over the turning down of the Decca navigation system for aircraft traffic control. If you want to see a collection of reactions—press, parliamentary and so on—get hold of a copy of *Decca Navigator News* for April, 1960. Decca House, Albert Embankment, London, SE11.

A strictly utility job is *Site and Plant*, well suited, I imagine, to the needs of the people who are likely to be interested. No fancy cover and a "profile" type article No. 1 on Marples. No. 1 of Volume 1 came out on 13 May and the subscription is £1 14*s* 8*d* for 52 weeks, or exactly half that (work it out yourself) for 26 weeks. From Site Publications Limited, Bugle House, Noel Street, London, W1.

Harrap (182 High Holborn, London, WC1) have *The English Duden* at 29*s*, and it seems to be something new in dictionaries. It's pictorial and, what's more, combined with *Der grosze Duden* you get a complete pictorial English-German, German-English dictionary—they say. They have an intriguing leaflet showing, as samples, a bulldog and a television set's innards.

I can see I am going to be buried by the sales literature of the new *McGraw-Hill Encyclopaedia of Science and Technology*. The Special Pre-Publication Price is £61 11*s* 6*d* and librarians should start softening up the ground round the accounts department as soon as possible.

For many years there have been some excellent abstracts floating around that have been unavailable to the general public. This has led to a feeling of great frustration in the breasts of librarians who were not counted among those privileged to receive them but who saw copies and yearned for them. Much of this has now been put right. From July it will be possible to buy *Index Aeronauticus* from Ministry of Aviation, TIL Room 115, Leysdown Road, Mottingham, London, SE9. The price is 8*s* 6*d* a single copy or five guineas a year (12 issues). *Aeronauticus*, by the way, also covers such material as metallurgy, thermodynamics, workshop processes, servos, optics, plastics and so on, so there is something for everyone.

I notice with considerable delight that the British Society of Gastroenterology and the British Medical Association are joining forces to produce a new quarterly journal to be called *Gut*.

Milling and Drilling

History of the Milling Machine: A Study in Technical Development. By ROBERT S. WOODBURY. Technology Monographs Historical Series Number Three. *The Technology Press, Massachusetts Institute of Technology, Cambridge 39, Massachusetts, USA* ($3.50)

Cutting Tools, Jigs and Fixtures. By H. C. TOWN. *Odhams Press.* (25*s*)

The milling machine occupies a special position in the genealogical tree of the machine tool family. It is one of the few basic types developed almost entirely outside this country during the Golden Age of British machine tool building in the first half of the 19th century. For many years after Eli Whitney and Robert Johnson built their first plain milling machines in the United States about 1818, the generally conservative British manufacturers of that period were reluctant to concede that the milling process had practical advantages over planing and shaping.

Although Mr. Woodbury suggests in his monograph that this passive resistance did not end until 1890 or 1910, some British engineers had certainly used the milling process very successfully before 1864. And as the author himself points out, James Nasmyth, that gifted and canny Scot, did in fact construct the first British milling machine—a machine for machining the sides of nuts—in 1830.

Nevertheless, the crucial improvements in the design and construction of the milling machine long continued to be made, principally in the north-eastern states of the USA, where the author now lives. He has turned his local knowledge and associations to excellent account in reconstructing the long and often complicated chain of events which has transformed the small crude bench-mounted machines of the pioneers to the rugged tape-controlled giants of today.

Although the author rightly scorns stylistic flourishes in a work of this kind, his narrative is always readable for he has packed his hundred pages with interesting fact and apt interpretative comment. His judgment of technical significance is penetrating; his passion for historical truth uncompromising; and his patience in tracking down original sources evidently inexhaustible. He has kept his quite narrow subject sharply in focus throughout, and hardly ever swings his sights to follow the many hares that start during the pursuit of historical fact.

At the very end of his book, however, Mr. Woodbury nods a little by compressing into a few short paragraphs a commentary on recent happenings. Engineering historians have many jobs to do, but contemporary documentation is hardly one of them. It should be left to scientific journals, institution papers, research reports and technical periodicals, organs that sustain the engineer in his daily work. The best of them also serve the needs of posterity.

Projected on the scale of history, successive weekly or monthly pages become a lively cinematographic record of progress seen against the gradual drift of the great general movements of engineering which cut down to size each component of the total advance. It is to sources like these that Mr. Woodbury's successors in, say, 2060 should have to turn when they are about to pronounce definitive judgments on their rude forebears of the 1950's.

The general excellence of his book may, however, easily beguile a later and less meticulous writer into too easy an acceptance of Mr. Woodbury's necessarily incomplete comments on the nearly contemporary scene. These remarks are prompted simply by the certain knowledge that future historians will dip frequently—and profitably—not only into Mr. Woodbury's history of milling machines, but also into the further histories he and others will yet write in the important series being published by the Massachusetts Institute of Technology.

Where the above publication has depth, Mr. Town's book on *Cutting Tools, Jigs and Fixtures* has width. At times, indeed, excessive width, for he tends to hover breathlessly over his topic for a moment or two before moving on abruptly to the next. Nor are all his statements supported by the steadily swelling stream of empirically derived data now flowing into industry. When discussing drill shape, for example, Mr. Town makes a good case for not deviating from the 118° point angle often used for general purposes. However, research has shown that drill performance can be greatly improved by varying point angle over a range of about 60° when drilling common engineering materials. The attentive reader will also no doubt speculate why, in a 12½ page chapter entitled "The Choice of Machining Methods," 10 pages are devoted to the detail design of bushes, clamps and locating devices for jigs and fixtures. Most of Mr. Town's illustrations are a model for books of this type.

Gesellschaft zur Förderung der Forschung auf dem Gebiet der Bohr- und Schiesstechnik: Untersuchungen über das Drehschlagbohren. *Westdeutscher Verlag, Ophovener Strasse 3, Opladen/Rhld.* (16.80 *DM*)

Patient investigation has also preceded the report on percussive-rotary drilling (drilling of another kind) published by the Society for the Advancement of Research into Drilling and Blasting, Essen. The research results are contained in a mimeographed document that represents a very useful contribution to the literature on the subject. During the course of the investigations valuable data were accumulated about the influence exerted by a number of variables on drilling speed, depth of cut, power consumption and so on.

J. R. TROTTER

Rolling Mills

Mekhanicheskoye Oborudovaniye Prokatnikh Tsekhov. By A. A. KOROLYOV. *Gosudarstvennoye Nauchno-Tekhnicheskoye Izdatelstvo Literaturi po Chernoi i Tsvetnoi Metallurgii, Moscow.* (21 *roubles* 30 *kopecs*)

Modern rolling mills are the subject of this 495-page Russian book, which also discusses methods of mill calculation and design. In the theoretical and experimental part, the sections are based on the author's previous work in his books "Mechanical Equipment of Rolling Mills" (1953) and "Rolling Mills: Design and Calculation" (1958) (reviewed in ENGINEERING, vol. 186, 1958, p. 713). New origina land theoretical research in the field of metal pressure on the rolls during rolling, calculations relating to straightening machines and tube rolling mills, and other advances are reported. In some of the calculation work, the author has been governed by methods developed by Professor A. I. Tselikov and published in the latter's book "Rolling Mills" (1946).

The description of new rolling mills in the Soviet Union is based on material produced by the Central Design Bureau for Metallurgical Engineering, the State Planning Council for Metallurgical Works and the Uralmash, Novo-Kramstorsk and Staro-Kramstorsk factories.

Much attention is paid to automatic control and its developments in rolling mills, and the latest information is given concerning principles of automatic control as used in the complex automation of rolling mills. The information on equipment for tube rolling mills is somewhat more compressed since there exist several separate books on this subject.

The 144-item bibliography consists entirely of Russian references but unfortunately Soviet technical book producers have still not got around to including a detailed index. The 19 chapters of the book are arranged under main headings as follows: fundamental calculations in the classification of rolling mills; general nature of rolling mill equipment; transportation, tilting and manipulating mechanisms; cogging and billet mills; rail, beam and section mills; plate and sheet mills (hot and cold); tube rolling mills; and automatic control of rolling mills. The automatic control section covers automation of the main electric motors, screw-down and ingot buggy in hot reversing mills; automation of the drives, flying shears and thickness measurement in hot continuous strip mills; and automation of the pickling line, strip thickness, roll pressure and tension in cold rolling mills.

Of particular interest is a table showing the classification of rolling mills which, in addition to nomenclature, gives details of starting blooms and billets and of the corresponding finished rolled products, particulars of the main drives and motors and of electric power, fuel, water and roll consumptions.

R. SEWELL

Numerical Tools for Multi-Parameter Processes

Probability and Statistical Inference for Engineers. By CYRUS DERMAN and MORTON KLEIN. *Oxford University Press.* (30*s*)

Rapid Statistical Calculations. By M. H. QUENOUILLE. *Charles Griffin.* (10*s*)

Modern methods of mass production make statistical control of the product essential. Thus every production engineer requires an understanding of at least elementary statistics. Research engineers, too, require to understand, if not necessarily to practice, statistical methods, since it is generally impossible to adopt the classical approach to experiments by varying one parameter at a time. In tuning up a complicated machine or plant such a method is frequently impossible even if time and money permitted its application.

When considering how engineering students should be introduced to statistics, it is necessary to recognise that the art—for there is art as well as science in the successful application of statistics—can vary from the ultra-pure papers which statisticians write for statisticians and which no one else can understand, to the forthright and elementary approach to British Standards BS 600: 1935, "Application of Statistical Methods to Industrial Standardisation and Quality Control," and BS 600R: 1942 "Quality Control Charts." Somewhere between lies the optimum approach which enables the engineer either to apply his knowledge profitably to his work, or better, to make the best use of the help which a professional statistician can offer—better because a statistician has many more weapons in his armoury than the amateur is likely to deploy and also because it is well to avoid doing for oneself the brute arithmetic labour of many statistical computations.

The first of the two books under review is described as "a one-semester course of study . . . directed towards engineering students" and as based on "an undergraduate course offered in the Department of Industrial and Management Engineering at . . . Columbia University." The approach is very pure and, although some excellent examples are given, it is most unlikely that any but the most brilliant students taking such a course would wish to study the subject further or become confident in the application to his future professional work of the methods he has been taught.

It is suggested that the simple and less rigorous approach used in many British textbooks, for example, *Statistical Methods in Research and Production*, by O. L. Davies (Oliver and Boyd, 1957), is more likely to win approval from and be useful to engineers. *Rapid Statistical Calculations* is a very different book. It is frankly an *aide-memoire* of computing methods for those who have digested and sporadically applied statistical methods. It usefully goes further and informs the reader how far he may go in approximate methods and what are the likely consequences of applying the various methods provided to non-Gaussian data. One feels that such a book may have a limited application. It is unlikely to appeal to the working statistician in full practice while the occasional user may be well advised to go back to his basic notes or textbook lest he fall into the manifold pits of "inapplicability" which beset applied statistics.

G. MORRIS

Evanescent Abacus Made Permanent in Prose

Science and Civilisation in China. Volume 3. By JOSEPH NEEDHAM. *Cambridge University Press.* (150*s*)

Dr. Needham's avowed aim is to provide a work of interest not merely to scientists, but to "humanists and all of general culture." Such studies, he argues, in which unfamiliar achievements of man in the pursuit of knowledge are explored and analysed, "are the only means of seeing the scientific activities of our own time in true perspective, one of the most useful ways of humanising technical education, and an indispensible part of the history of civilisation as a whole."

With this volume he resumes his study of Chinese science, exposing once again the ignorance and condescension of the West. In the introductory volumes he dealt with the history, geography and language of China, and with the influence of religion and philosophy on scientific thought. Now he plunges into the crucial subject of mathematics.

Ancient Chinese mathematics, it appears, could stand comparison with that of Babylon and Arabia. If it did not develop systematically in the modern manner, this was largely due to the organic and practical bias in Chinese thought; calculations were reported in prose or done quickly but impermanently on the abacus. The synthesis of mathematics and the natural sciences which produced modern science in the West Dr. Needham is inclined cautiously to put down to political and economic conditions very different from those of China; to the freedom, individualism and quantitative emphasis of nascent capitalist society.

The section on astronomy takes up nearly half the book, and its length reflects the scant respect shown to Chinese work in this field by Western scientific commentators. Of particular interest to engineers are the gnomons, water-clocks and armillary spheres which are amply illustrated and discussed. In contrast to Western Europe, where astronomy between the Greeks and the Renaissance was largely overshadowed by religious cosmology, the Chinese had throughout this period an active tradition of observation of the heavens. They held to polar and equatorial coordinates and accepted the idea of an infinite universe when Europe was thinking in terms of crystal spheres or struggling with ecliptic coordinates.

In geography the Chinese again displayed a freedom from theoretical cosmology; when map-making in the West was dying out with the Hellenistic philosophers the Chinese were "initiating a long line of scientific mapmakers" whose work was brought together on a rectangular grid. A section on seismography shows reconstructions of a seismograph dating from 132 AD; and there are sections on meteorology, geology and mineralogy.

These notes can only give a superficial impression of Dr. Needham's sensitive and detailed approach to his topics; but they may suggest how well he succeeds in interesting the "humanist" reader, scientific or otherwise, even without the help of his many fascinating and often beautiful illustrations. Although this reviewer cannot judge the scholarship, he can marvel at Dr. Needham's ease in adopting the language of different sciences; his 200 pages of bibliographies and indexes; his learned disquisitions on disputed points; his multitude of footnotes, including the characters of all the Chinese words in the text; and above all his first-hand knowledge of his many Chinese sources.

C. J. ALBU

Employee Give-Aways in the Job Package

Fringe Benefits. By FRANCIS M. WISTERT. *Reinhold, New York; Chapman and Hall, London.* (30*s*)

This book may appear somewhat expensive on this side of the Atlantic and limited in its usefulness, nevertheless it gives much useful information on a subject which is of considerable interest to British industry. The words "fringe benefits" cover a wide range of perquisites. One can go back a long way if one wishes to trace their origin, but two facts have today made the distribution of indirect rewards a flourishing practice. These are full employment and high taxation.

In the American context, with which this book is concerned, a number of paternalistic-minded companies had built up benefits outside formal or contractual remuneration over a long period of years. Many of these were swept away by the Great Depression. In consequence, after the Second World War, the development of fringe benefits began almost from the start again—but it travelled very fast. The same was broadly true in this country.

The book deals with several kinds of benefit. These include holidays, various types of superannuation, payment for time not worked, guaranteed annual wage, supplementary unemployment benefits and miscellaneous benefits. These last include sponsored education schemes, tuition refunds, educational loans, subsidised meals, housing, profit sharing, recreation programmes, suggestion plan awards and working clothes. There is also a concluding chapter on the economic aspect of fringe benefits. The style of writing is economical and the index makes reference to topics easy.

Fringe benefits can teeter on the edge of the farcical, and not only in the United States. In this book those who wish to see how far concessions to workers can go will find the chapter on

Continued on next page

holidays particularly illuminating. The extreme case in the author's experience is a plant which gave a holiday to operatives on the shop steward's birthday. Saints and shop stewards are fast becoming one in this highly industrial world.

The main use of this book to those in British industry is to see how far fringe benefits have gone, both in principle and application in a country which still sets the fashion in many things industrial. If we worship at the altar of American mass-production efficiency we must needs do obeisence to some extent to that economy's foibles in human relations. The importance of watching the Americans in this field is all the more underlined because they have travelled so far so quickly.

In many ways labour relations in this country have travelled in the quite distant past a road which the United States is following in the last generation. The fact that a continuing high rate of technical change in that country has recently been accompanied by a very fast rate of development in human relations (not just in textbooks but also on the shop floor) makes their study all the more interesting to ourselves. They may yet set a pace of fringe concessions to workers which will have a profound effect over here.

This has already happened to some extent in the case of the guaranteed annual wages. Other ideas may also gain a hearing in Britain. So far the trade union movement in this country has not been very receptive to ideas developed in the United States (less so than management) but that may not always be so.

G. E. TEWSON

Noble Refugee Made Good in Engineering

Sir Casimir Stanislaus Gzowski: A Biography. By LUDWIK KOS-RABCEWICZ-ZUBKOWSKI and WILLIAM EDWARD GREENING. *Burns and MacEachern, 12 Grenville Street, Toronto 2.* ($4·75)

The man of good birth who found fame and fortune on the frontier in North America last century is a well-authenticated type. The émigré of noble birth who found success, with courage, drive, shrewdness and technical expertise was much rarer. Such a man was Sir Casimir Gzowski.

After taking part in an unsuccessful Polish insurrection in 1832, he elected to be transported to the United States with other dissident Polish officers. He landed in New York without money, friends or a knowledge of English. He died in 1898 at the age of 85—knighted, honorary *aide-de-camp* to Queen Victoria and an esteemed member of many Canadian societies (Canada was his land of adoption) and of others abroad—including engineering affiliations, honorary and otherwise.

His very considerable reputation in Canada was built on his work in Quebec and Ontario in developing the road, rail and canal systems. His combination of charm and ability brought him wealth, distinction and influence—this last far outside his work as an engineer. He was clearly an able engineer (his best known achievement was the international bridge between Buffalo and Fort Erie joining the United States and Canada). He may have even been a card.

This biography has been published under the auspices of the Engineering Institute of Canada. The material, perhaps inevitably, is thin in places and an obituary style of writing has not been helped by the duality of the authorship.

The value of the book is in its assembly of facts about the early history of the engineering profession in Canada. In consequence it would have benefited very much from a really good index. The one provided could have been usefully extended at the expense of some of the appendices. It will be a useful source of information in a limited field.

G. E. TEWSON

New Books

Plant Engineering Handbook. Edited by WILLIAM STANIAR. 2nd edition. *McGraw-Hill, New York and London.* (182*s*)

Over 2,000 pages of materials, processes, equipment and methods prepared by a staff of specialists drawn from industry, teaching and research. This edition has new sections covering advances in standardisation, heating of buildings, automation, synthetic lubricants and industrial electronics.

A Treatise on Algebraic Plane Curves. By JULIAN LOWELL COOLIDGE. *Dover Publications, New York; Constable, London.* (20*s*)

In the original edition, of which this is a facsimile reprint, Dr. Coolidge justified the addition of another title to the then current annual increment of 4,000 contributions to mathematical science by giving as his object a survey of the present status of the theory of algebraic plane curves and their relations to various fields of geometry and analysis.

Tabulation of Data on Receiving Tubes. By C. P. MARSDEN, W. J. KEERY and J. K. MOFFITT. National Bureau of Standards Handbook No. 68. *US Government Printing Office, Washington; HM Stationery Office, London.* (9*s*)

The NBS Electron Devices Data Service was set up to provide information for Bureau staff, and has since been extended to all scientists in government and industry in the USA. During the course of the programme a large volume of information on US and foreign tubes was accumulated on punched cards, and it was therefore possible to produce this list by automatic printing.

Absperrorgane in Rohrleitungen. By WALTHER VOLK. *Springer-Verlag, Heidelberger Platz 3, Berlin-Wilmersdorf.* (25·50 *DM*)

Control valves in pipe systems, considering the design, construction and operation of plug, gate, butterfly, non-return and other types of control.

The Electrical Year Book, 1960. 53rd edition. *Emmott and Company Limited, 31 King Street West, Manchester 3.* (4*s*)

A pocket-sized reference book on electrical practice and applications, with a useful selection of tables.

Mathematics for Telecommunication Engineers. By S. J. COTTON. *Chapman and Hall.* (37*s* 6*d*)

The author excuses his adding yet another textbook on mathematics to the shelves, by its function: to bridge the gap between the level of mathematics reached in HNC courses and that required for the intelligent reading of professional journals, and for everyday professional problems.

Theoretical Elasticity. By CARL E. PEARSON. *Harvard University Press, Cambridge, Mass.; Oxford University Press, London.* (48*s*)

The purpose of this book is in part to discuss modern methods of elasticity theory in a form which does not require extensive mathematical experience, and in part to provide a compact and convenient summary of these methods.

Elements of Calculus and Analytic Geometry. By GEORGE B. THOMAS, JR. *Addison-Wesley Publishing Company, Reading, Mass. and London.* (57*s*)

Based on the author's *Calculus and Analytic Geometry*, this text is designed as a one year university course, assuming a knowledge of algebra, geometry and some trigonometry.

Elektrische Antriebe. By ADOLF LEONHARD. 2nd edition. *Ferdinand Enke Verlag, Hasenbergsteige 3, Stuttgart W.* (43 *DM*)

The new edition of Professor Leonhard's book on electric motors and drives contains added sections on the development of electric drives from 1879, when Siemens produced his narrow-gauge railway, on control, and on electric traction.

Progress in Nuclear Physics. Volume 7. Edited by O. R. FRISCH. *Pergamon Press.* (84*s*)

Six papers make up the latest volume in this series; they deal with the bubble chamber, resonance fluorescence in nuclei, spallation, an optical model for nuclear scattering, the measurement of helicity, and weak interactions.

Proceedings of the Sixth Midwestern Conference on Fluid Mechanics, September, 1959. *The University of Texas, Austin, Texas.* ($12·50)

The 30 papers presented included a review of progress in rarefied gas dynamics research, and contributions on gas lubricated bearings and boundary layer research.

Problems in Electrical Engineering. By S. PARKER SMITH. Edited by N. N. Parker Smith. 7th edition. *Constable.* (20*s*)

The addition of just over 100 new problems brings the total up to 1,981, the expansion being mainly in the field of electronics. Most of the problems are stated in both mks and cgs units for general convenience.

Trade Publications

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Materials

Expanded Rubber. EXPANDED RUBBER CO. LTD., Mitcham Road, Croydon, Surrey. Seven-page booklet illustrated with diagrams—three on gaskets, three on thermal insulation tubing and one on open cell gasketing in continuous lengths.

Paints for Marine Use. JOHN S. CRAIG AND CO. LTD., Bogmoor Road, Glasgow, SW1. Painting of shot blasted steel, specialised protective treatment for aluminium and galvanised iron and time tested anticorrosive protectives and finishes are among subjects covered in this manual.

Plastic Laminates. MICANITE AND INSULATORS CO., LTD., Blackhorse Lane, Walthamstow, London, E17. Sixteen page illustrated booklet on Paxolin tubes and cylinders. Latest property data and information on how to work the material.

Caustic Soda. SOLVAY ET CIE, 33 Rue Prince Albert, Brussels, 5. This 60-page glossy is attractively presented and will tell you (in French) all about caustic soda if you wish to buy it from the Continent.

The Reviewers

Mr. J. R. Trotter is the Production Editor of ENGINEERING.

Mr. R. Sewell, who is a fellow of the Institute of Information Scientists, is information officer in the research and development department, United Steel Companies Limited. He was a member of the British Iron and Steel delegation to the USSR in 1956, and was responsible for the English version of the *Metallurgical Classification* of the Centre de Documentation Sidérurgique and for the basic work on corrections and additions for the 1958 edition of the *Stahleisen Wörterbuch* (iron and steel dictionary) published by the Verein Deutscher Eisenhüttenleute. Since its inception, Mr. Sewell has been chairman of the British Iron and Steel Industry Translation Service.

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Automation and Machine Tool Elements

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By F. Koenigsberger, D.Sc., M.I.Mech.E., M.I.Prod.E.

The Faculty of Technology, University of Manchester

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(*a*) Handling of the workpiece, which includes insertion into the machine, clamping, unclamping, and removal from the machine.
(*b*) Control of the cutting movements, which includes selection and setting of operational speeds, starting, stopping, and reversing.
(*c*) Control of setting and feed movements in accordance with a planned programme which includes selection and setting of feed rates, movement of tools into position, and starting, stopping and reversing of feed movements.
(*d*) Inspection of the results of the cutting operation. If the errors exceed the permissible tolerances this may involve either rejection of the workpiece and/or stopping of the machine, or correction of the tool setting and repetition of the operation until the correct result is obtained. It may alternatively involve checking the dimensions of the workpiece continuously and correcting, if necessary, the settings during the cutting operation.
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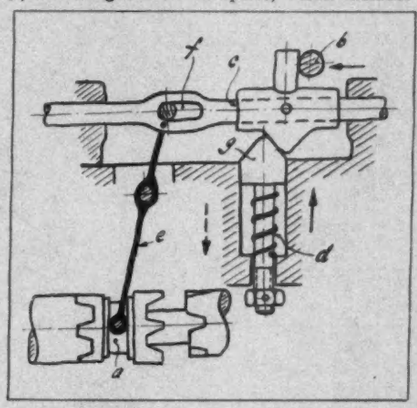

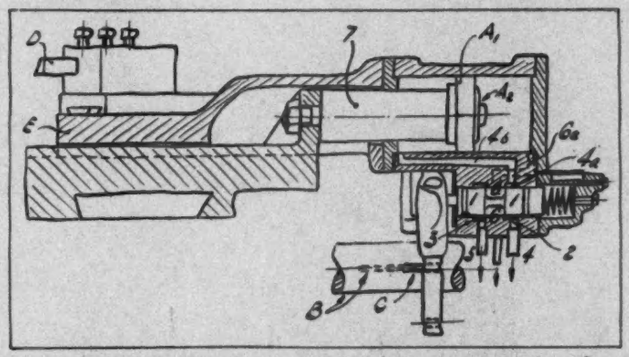

Fig. 1 (above left) A dog clutch, showing its spring powered quick operation.

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TWO PARTS

If an automatic control system replaces the work of the operator, each of the above functions has to be broken down into two parts: signals which start and stop the operation, and execution of the operation itself.

The production and transmission of the signals can be based on a time cycle, for example, by a shaft rotating at a given speed. This has long been used in automatic lathes in which a central constant speed camshaft makes one complete revolution during the production of a workpiece, the production time (T) for one piece being equal to the reciprocal value of the speed (n) of the control shaft $\left(T = \frac{1}{n}\right)$. Each operation is initiated and terminated by its appropriate cam on the control shaft at a given rotational angle of the shaft. After the completion of one workpiece and with each subsequent revolution of the camshaft the work cycle is repeated in an identical manner, starting with the feeding in of the bar material and finishing with the parting off of the finished workpiece. The position of the various control levers and tool carriers at any given moment depends solely upon the angle of rotation of the control shaft at that moment.

PUNCHED CARDS

A similar control action could be obtained from punched cards, punched or magnetic tape if these were so arranged as to produce only signals for starting and stopping various operations, irrespective of whether each operation has been completed satisfactorily before the next one is initiated. If, for instance, a certain operation could not be completed, because of wear or perhaps fracture of a load transmitting element or through the slipping of a clutch, the subsequent operation would still be initiated at the time determined by the progress of the controlling element.

A moving tool carrier, slide, or lever producing at the end of its working stroke a signal which initiates the next operational movement will overcome the difficulty of incomplete operations. The signal depends upon the position of the driven and not the driving element so that possible faults in the driving mechanism have no effect upon the accuracy of the signal. An example is the use of trip dogs on a milling machine table for starting, stopping and reversing the feed and quick traverse movements. The accuracy of the operation depends upon the setting of the trip dogs and the response of the control gear. The problem has also been solved electrically[1] when, for instance, the signal for each operational movement of a capstan lathe (opening of collet, feeding of bar material, closing of collet, forward movement of turret head, withdrawal of turret head, forward movement of cross-slide, withdrawal of cross-slide, etc.) has its own control circuit operated by a a switch. Once the required sequence of movements is set up, the limit switch at the end of a completed movement operates the starting switch for the next movement.

Instead of being produced by a feed or traversing movement the signal can also be produced and transmitted when the purpose of such a movement is accomplished, i.e., when the required operation itself is completed. The positioning of a moving part or the dimension produced by a cutting operation is measured and compared with a previously fixed value, and as soon as the measured value equals the required one within specified limits the signal is transmitted which terminates the movement and, if applicable, starts the next operation. For example, an operator initiates the setting movement of the table or slide on a boring machine. As soon as a signal produced by an independent measuring device indicates that the required position has been reached, the setting movement is stopped, the moving part clamped and the cutting operation started.

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Instead of carrying out measurements at the end of a traversing movement or of an operation, the instantaneous relative position of tool and workpiece (or tool carrier and workpiece carrier) can be measured and corrected continuously during the operation, error signals initiating the movements which have to take place until the signalled errors are zero. In the case of machining complex profiles these continuous measurements and corrections may have to be carried out simultaneously for different moving parts. This type of control requires, therefore, measuring devices which, independently of the machine and its moving parts, measure their relative positions and transmit error signals which, in turn, control the driving elements accordingly. Only this last step, the closing of the control loop, leads to complete automation, i.e., to operations in which the machine replaces completely the operator. The place of the drawing, the working specification for the operator, is then taken either by a master profile or by a "programme" which is introduced into the machine by means of a punched card, punched tape or magnetic tape (numerical control, see the article by R. C. Brewer on page 871).

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holidays particularly illuminating. The extreme case in the author's experience is a plant which gave a holiday to operatives on the shop steward's birthday. Saints and shop stewards are fast becoming one in this highly industrial world.

The main use of this book to those in British industry is to see how far fringe benefits have gone, both in principle and application in a country which still sets the fashion in many things industrial. If we worship at the altar of American mass-production efficiency we must needs do obeisence to some extent to that economy's foibles in human relations. The importance of watching the Americans in this field is all the more underlined because they have travelled so far so quickly.

In many ways labour relations in this country have travelled in the quite distant past a road which the United States is following in the last generation. The fact that a continuing high rate of technical change in that country has recently been accompanied by a very fast rate of development in human relations (not just in textbooks but also on the shop floor) makes their study all the more interesting to ourselves. They may yet set a pace of fringe concessions to workers which will have a profound effect over here.

This has already happened to some extent in the case of the guaranteed annual wages. Other ideas may also gain a hearing in Britain. So far the trade union movement in this country has not been very receptive to ideas developed in the United States (less so than management) but that may not always be so.

G. E. TEWSON

Noble Refugee Made Good in Engineering

Sir Casimir Stanislaus Gzowski: A Biography. By LUDWIK KOS-RABCEWICZ-ZUBKOWSKI and WILLIAM EDWARD GREENING. *Burns and MacEachern, 12 Grenville Street, Toronto 2.* ($4·75)

The man of good birth who found fame and fortune on the frontier in North America last century is a well-authenticated type. The émigré of noble birth who found success, with courage, drive, shrewdness and technical expertise was much rarer. Such a man was Sir Casimir Gzowski.

After taking part in an unsuccessful Polish insurrection in 1832, he elected to be transported to the United States with other dissident Polish officers. He landed in New York without money, friends or a knowledge of English. He died in 1898 at the age of 85—knighted, honorary *aide-de-camp* to Queen Victoria and an esteemed member of many Canadian societies (Canada was his land of adoption) and of others abroad—including engineering affiliations, honorary and otherwise.

His very considerable reputation in Canada was built on his work in Quebec and Ontario in developing the road, rail and canal systems. His combination of charm and ability brought him wealth, distinction and influence—this last far outside his work as an engineer. He was clearly an able engineer (his best known achievement was the international bridge between Buffalo and Fort Erie joining the United States and Canada). He may have even been a card.

This biography has been published under the auspices of the Engineering Institute of Canada. The material, perhaps inevitably, is thin in places and an obituary style of writing has not been helped by the duality of the authorship.

The value of the book is in its assembly of facts about the early history of the engineering profession in Canada. In consequence it would have benefited very much from a really good index. The one provided could have been usefully extended at the expense of some of the appendices. It will be a useful source of information in a limited field.

G. E. TEWSON

New Books

Plant Engineering Handbook. Edited by WILLIAM STANIAR. 2nd edition. *McGraw-Hill, New York and London.* (182*s*)

Over 2,000 pages of materials, processes, equipment and methods prepared by a staff of specialists drawn from industry, teaching and research. This edition has new sections covering advances in standardisation, heating of buildings, automation, synthetic lubricants and industrial electronics.

A Treatise on Algebraic Plane Curves. By JULIAN LOWELL COOLIDGE. *Dover Publications, New York; Constable, London.* (20*s*)

In the original edition, of which this is a facsimile reprint, Dr. Coolidge justified the addition of another title to the then current annual increment of 4,000 contributions to mathematical science by giving as his object a survey of the present status of the theory of algebraic plane curves and their relations to various fields of geometry and analysis.

Tabulation of Data on Receiving Tubes. By C. P. MARSDEN, W. J. KEERY and J. K. MOFFITT. National Bureau of Standards Handbook No. 68. *US Government Printing Office, Washington; HM Stationery Office, London.* (9*s*)

The NBS Electron Devices Data Service was set up to provide information for Bureau staff, and has since been extended to all scientists in government and industry in the USA. During the course of the programme a large volume of information on US and foreign tubes was accumulated on punched cards, and it was therefore possible to produce this list by automatic printing.

Absperrorgane in Rohrleitungen. By WALTHER VOLK. *Springer-Verlag, Heidelberger Platz 3, Berlin-Wilmersdorf.* (25·50 *DM*)

Control valves in pipe systems, considering the design, construction and operation of plug, gate, butterfly, non-return and other types of control.

The Electrical Year Book, 1960. 53rd edition. *Emmott and Company Limited, 31 King Street West, Manchester 3.* (4*s*)

A pocket-sized reference book on electrical practice and applications, with a useful selection of tables.

Mathematics for Telecommunication Engineers. By S. J. COTTON. *Chapman and Hall.* (37*s* 6*d*)

The author excuses his adding yet another textbook on mathematics to the shelves, by its function: to bridge the gap between the level of mathematics reached in HNC courses and that required for the intelligent reading of professional journals, and for everyday professional problems.

Theoretical Elasticity. By CARL E. PEARSON. *Harvard University Press, Cambridge, Mass.; Oxford University Press, London.* (48*s*)

The purpose of this book is in part to discuss modern methods of elasticity theory in a form which does not require extensive mathematical experience, and in part to provide a compact and convenient summary of these methods.

Elements of Calculus and Analytic Geometry. By GEORGE B. THOMAS, JR. *Addison-Wesley Publishing Company, Reading, Mass. and London.* (57*s*)

Based on the author's *Calculus and Analytic Geometry*, this text is designed as a one year university course, assuming a knowledge of algebra, geometry and some trigonometry.

Elektrische Antriebe. By ADOLF LEONHARD. 2nd edition. *Ferdinand Enke Verlag, Hasenbergsteige 3, Stuttgart W.* (43 *DM*)

The new edition of Professor Leonhard's book on electric motors and drives contains added sections on the development of electric drives from 1879, when Siemens produced his narrow-gauge railway, on control, and on electric traction.

Progress in Nuclear Physics. Volume 7. Edited by O. R. FRISCH. *Pergamon Press.* (84*s*)

Six papers make up the latest volume in this series; they deal with the bubble chamber, resonance fluorescence in nuclei, spallation, an optical model for nuclear scattering, the measurement of helicity, and weak interactions.

Proceedings of the Sixth Midwestern Conference on Fluid Mechanics, September, 1959. *The University of Texas, Austin, Texas.* ($12·50)

The 30 papers presented included a review of progress in rarefied gas dynamics research, and contributions on gas lubricated bearings and boundary layer research.

Problems in Electrical Engineering. By S. PARKER SMITH. Edited by N. N. Parker Smith. 7th edition. *Constable.* (20*s*)

The addition of just over 100 new problems brings the total up to 1,981, the expansion being mainly in the field of electronics. Most of the problems are stated in both mks and cgs units for general convenience.

Trade Publications

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Materials

Expanded Rubber. EXPANDED RUBBER CO. LTD., Mitcham Road, Croydon, Surrey. Seven-page booklet illustrated with diagrams—three on gaskets, three on thermal insulation tubing and one on open cell gasketing in continuous lengths.

Paints for Marine Use. JOHN S. CRAIG AND CO. LTD., Bogmoor Road, Glasgow, SW1. Painting of shot blasted steel, specialised protective treatment for aluminium and galvanised iron and time tested anticorrosive protectives and finishes are among subjects covered in this manual.

Plastic Laminates. MICANITE AND INSULATORS CO., LTD., Blackhorse Lane, Walthamstow, London, E17. Sixteen page illustrated booklet on Paxolin tubes and cylinders. Latest property data and information on how to work the material.

Caustic Soda. SOLVAY ET CIE, 33 Rue Prince Albert, Brussels, 5. This 60-page glossy is attractively presented and will tell you (in French) all about caustic soda if you wish to buy it from the Continent.

The Reviewers

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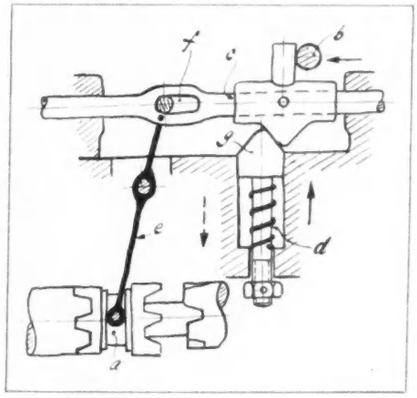

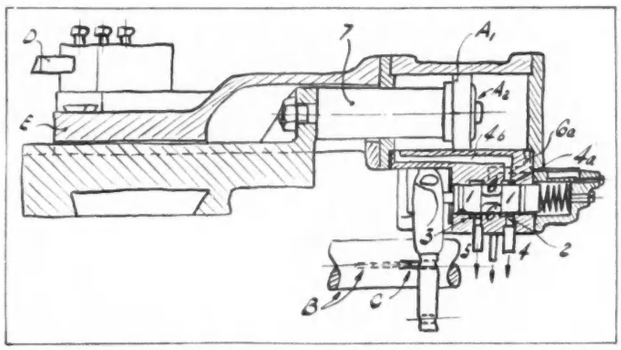

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ment lies in its great simplicity, its drawback is the need for the strength of the signal transmitting elements to be high enough to satisfy the requirements of energy transmission. This may result in reduced speeds of signal transmission, less accurate work due to inevitable deformation and wear of highly loaded machine elements. In addition, the speed of the camshaft is set by the time cycle of the operations in question, and this can result in uneconomically low working speeds.

SELF ENERGISING

The energy can be provided by the moving part itself when, for instance, a table movement is halted by a trip dog moving a switch or a lever and thus stopping a driving motor or disengaging a clutch. The speed of such an operation depends on the speed of the moving part.

The problem becomes more difficult if one movement has to be started after the preceding one has already ceased. In this case the kinetic energy of the first movement can be stored and released for the subsequent control operation. An example is the spring powered quick operation of a dog clutch (*a*) by a trip dog (*b*) on a moving slide (Fig. 1). When the trip dog pushes cam and bar (*c*) to the left it compresses spring (*d*), while clutch lever (*e*) and clutch (*a*) are unaffected because of slot (*f*). Only when the cam on (*c*) has passed the peak of the cam on spring bolt (*g*), has fully compressed spring (*d*) and when the right-hand side of slot (*f*) touches the top of clutch lever (*e*), will the spring push upwards and throw bar (*c*) to the left thus switching the clutch into its opposite position.

Only complete separation of signal and energy transmission leads to the full exploitation of the possibilities offered by automatic control Not only does it provide adequate control energy for all requirements, but also make possible the application of various combinations of electrical, mechanical, hydraulic and pneumatic means.

MEASUREMENTS

Today information is provided, measurements are taken and signals are transmitted by mechanical, hydraulic, pneumatic or electronic means. The signals operate electric switchgear, hydraulic valves or mechanical clutches which in turn control the electric, hydraulic or mechanical power input for the various cutting, setting and traversing movements, etc.

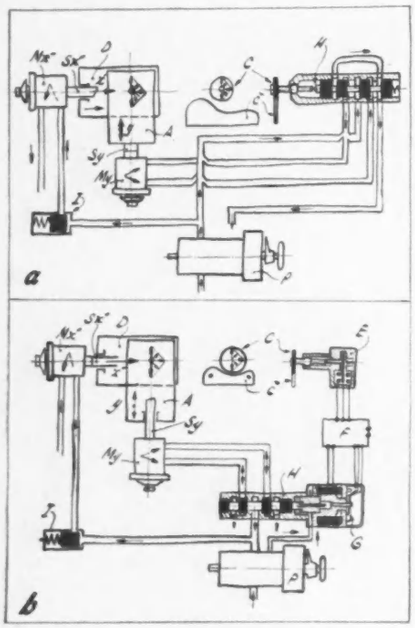

Fig. 3 The feed drive control of a profile milling machine.

The machine tool becomes part of the servo-mechanisms, the performance of which is influenced not only by the quality of its control elements but also by the design and manufacture of the machine tool itself. The stiffness and mass of various elements, the natural frequencies of vibrating systems, the friction conditions between sliding parts (especially "stick-slip"), backlash between mating components, etc., affect the response and stability of the servo. The possibility of executing several operations simultaneously and the higher operating speeds used result in larger power requirements which must be satisfied in order to ensure consistent and reliable operation.[2]

The idea of separating mechanical signal and energy transmission in machine tools was perhaps first applied in the Brown and Sharpe automatic lathe. On this machine one camshaft provides the signal impulses which engage and disengage clutches on a second, independently driven, shaft, thus coupling it with different cams which in turn move slides, operate clamping levers, and so on.

COPYING

A valve which is mechanically operated by a template and which controls the movement of a piston in a hydraulic cylinder is used in the copying device (Fig. 2) for a centre lathe. This device is produced as a self-contained unit and can be attached to any lathe of suitable size. By arranging the direction of the in-feed movement at 45° to the turning axis it is possible to machine shoulders and facings at right angles to the axis. The hydraulic cylinder forms one piece with the tool slide (E) and moves in relation to the piston which is fixed to the saddle of the lathe. Both sides of the piston are under oil pressure. The in-feed is controlled by valve spool (1). If this is in its central position inlets (2) and (3) are equally open. The oil delivered through pipe (4) is thus returned to tank through pipe (5) via chamber (6). With a supply pressure "p" in pipe (4) and equal throttling in (2) and (3), the pressure drop in (3) is equal to that in (4), at $\frac{p}{2}$. If the spool (1) is in its middle position, the pressure in chamber (6) is $\frac{p}{2}$.

The piston is designed in such a manner that the annular area A_1 on the left is half the area A_2 on the right ($A_2 = 2A_1$). A_1 is under oil pressure from pipe (4) through channels (4a) and (4b), while A_2 is under oil pressure from chamber (6) through channel (6a). In the middle position of spool (1) the pressure on A_1 is therefore p_1 and on A_2: $\frac{p}{2}$. The piston is inequilibrium, because

$$A_2 \times \frac{p}{2} = 2A_1 \times \frac{p}{2} = A_1 \times p$$

If, during the longitudinal movement of the saddle along the template (B), tracer (C) is moved forward or backwards, and gives thus an error signal, the equilibrium is disturbed and slide (E) with tool (D) moves until the equilibrium is re-established and the tool (D) is in a position corresponding to tracer (C) on template (B).

The feed drive control of a profile milling machine (Fig. 3) provides an example of hydraulic control combined with a mechanical drive. Valve (H) controls the oil delivered by pump (P) to the hydraulic motor M_y, which drives table (A) along the y-axis by means of screw (S_y). The cross slide feed along the x-axis is driven by hydraulic motor (M_x) which is supplied directly by pump (P) via pressure valve (I). A tracer (C) fixed to the spindle head and carrying a roller of a diameter equal to that of the cutter, slides along the master profile (*c*) which is located near the workpiece on the machine table (A).

HYDRAULIC VALVE

The hydraulic valve (H) is controlled by tracer (C) either mechanically (Fig. 3a), or electronically (Fig. 3b). In the first case (Fig. 3a), the tracer movement, i.e. the signal indicating the difference between the relative positions at any moment between workpiece and cutter on the one hand and master profile and tracer roller on the other hand, acts directly on the valve spool.

In the second case (Fig. 3b), the tracer (C) controls valve spool (H) via electronic gauge (E), amplifier (F) and solenoid (G). One advantage of this system is the fact that flexible or telescopic pipes between the unit tracer-valve and the hydraulic drive are not needed.

The examples which have been quoted apply to operations where a single tool machines a single workpiece which is securely clamped to the machine table or held in a chuck. The problem becomes more complex when different tools have to operate successively on a single workpiece or if workpieces have to be fed continuously into the machine at a steady flow. The idea of holding the tools in a turret head and swinging them into their working position when required, well known for capstan and automatic lathes, has recently been applied to milling and drilling machines.

AUTOMATIC ROTATION

A design for automatic mechanical rotation with hydraulic indexing and clamping of the turret head for drilling machines is shown in Fig. 4. An important detail is the fact that only the particular tool, which is in the working position, is actually power driven, its driving gear (A) being swung out of mesh with the main driving pinion (B) as soon as the turret rotation moves it away from its vertical downward position.

The examples so far discussed refer mainly to items (b), (c) and (d) quoted in the opening paragraphs. They concern specific single types and a limited number of operations (turning, grinding, milling, drilling).

When the types of operation, which have to be covered by an automatic cycle, become so varied and the number so large that the required tool set-up cannot be accommodated around one workpiece station, the workpiece is transported from one machine or one tooling station to another either by itself or in its clamping device. Instead of letting it slide along a roller path, down a chute, or arranging for it to be carried on a bogey or in a cage, the transport may have to be positively controlled with the workpiece held in its clamping fixture or chuck. This leads to the transfer line, the idea of which can also be incorporated in a single machine where

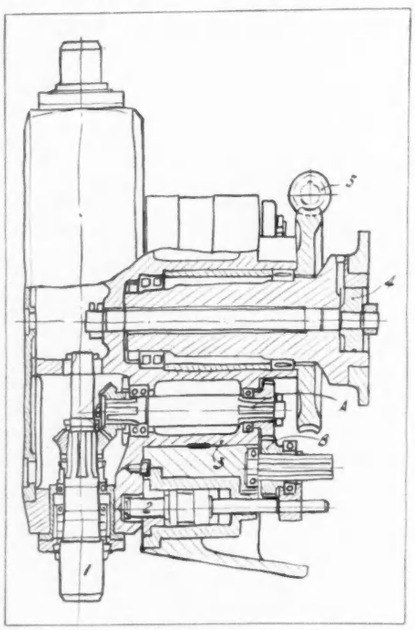

Fig. 4 A design for automatic mechanical rotation with hydraulic indexing and clamping of the turret head for drilling machines.

Numerically Controlled Machine Tools

The methods and requirements of numerical machine tool control are reviewed. There is a gap to be bridged between the control engineer and the machine tool user. The economics of numerical control need to be analysed more fully.

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THE OBJECT of dimensional control by analogue and digital methods, known collectively as numerical control, is to render as automatic as possible, all those stages between the designer's final thoughts and the actual machining of a component. Although this object cannot, as yet, be achieved completely, the concept is there and is in contradistinction to that of merely balancing heavy initial costs against large numbers produced. This latter concept, on which the majority of previous automatic working methods have been based, fails most lamentably when very complex components are required in small numbers and it is here that the more refined methods of numerical control have greater success.

It is not suggested that numerical control is exempt from normal economic "laws"; there is an initial cost to equip a machine tool with a control system (varying from just under £1,000 to over £10,000 in quite a number of cases and this will inevitably increase the hourly cost of running the machine. Furthermore, there is a cost for preparing the machine each time a new batch of components is produced and this cost must be shared by the components produced. Thus, the curve of cost per component against number of components is the usual rectangular hyperbola (Fig. 1), asymptotic to the invariable cost per component. The most characteristic feature of numerical control, however, is the rapidity with which the cost curve falls. Obviously many factors influence its rate of fall but, at the order of a dozen components, the variable costs are usually almost zero. It is clear then that the field of application for numerical control is batch rather than mass production.

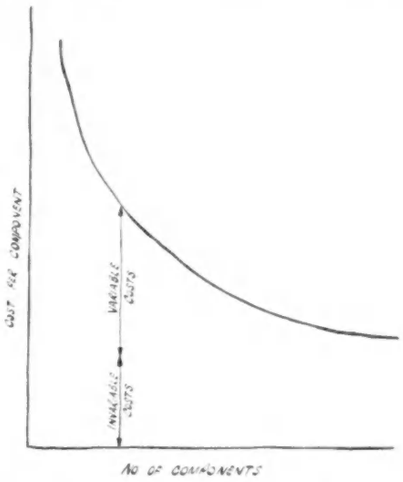

Fig. 1 The graph shows the relationship of cost per component and number of components for a machine fitted with numerical control.

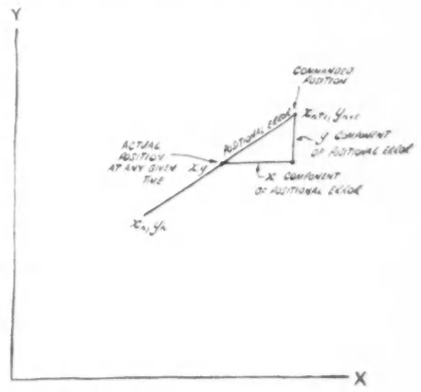

Fig. 2 It is the aim of the designer to reduce the resolved parts of the positional error to a minimum.

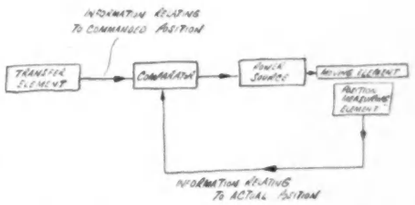

Fig. 3 A block diagram showing the main elements of an automatic control system.

OBJECT

Let us now return to our consideration of the object of numerical control. It must be conceded as impractical, certainly at the moment, to render automatic every stage from the designer's thoughts to the actual machining; for example, we must accept that the designer will have to express his thoughts in some normal form of intelligence such as the conventional engineering drawing. Although not the most apt form for linking the design and production stages where numerical control is concerned, the normal engineering drawing has many advantages to the designer which are quite unconnected with production and the possibility of this type of drawing disappearing is remote.

The first point at which numerical control differs from conventional machining is the preparation of a coordinate drawing. This may be two- or three-dimensional (according to the nature of the component) and the locations of all major points are indicated by means of their coordinates with respect to some datum point. In expanding on what is meant by a "major point," it must be stressed that there are two basic types of problem to be met:—

(*a*) the problem of performing an operation, or group of operations, at several discrete points, e.g. the drilling of a series of holes in a plate. In this case, the centre of each hole is a major point and must be specified, but neither the path nor velocity of relative movement between major points is important—the moving element is only required to stop at each of the specified points. This type of control is variously known as positional control, positioning, point-to-point positioning, etc., and is virtually a two-dimensional problem.

(*b*) the problem of effecting continuous control on the path and velocity of relative movement between tool and workpiece. This problem is one stage more difficult than positional control, since, in theory, an infinite number of points is required to completely specify a line or surface. Fortunately, most surfaces met in engineering practice (and their traces in a plane) can be specified by a reasonably small amount of information, e.g. the line and the plane may be defined by the coordinates of two and three points respectively while a circular arc is completely identified by its initial and final points and its radius of curvature. Hence, when continuous control has to be effected over a curve in two dimensions or a surface in three dimensions, the major points are frequently the transition points where one curve (or surface) changes to another but more will be said on this point later. This type of control is known as continuous contour control, path control, contouring, etc.

As a useful adjunct to the coordinate drawing, the major points are usually numbered and a table of coordinates for all major points is

Continued on next page

Concluding **Automation and Machine Tool Elements**

the workpiece is moved, often on a rotary table, from one working station to the next. An example of this is the Ryder eight spindle automatic verticle chucking table which will machine two types of brake drum simultaneously.

The problems which today present themselves to the designer of automatic machine tools are often of a fundamental nature. They are in matter as well as in degree very different from those encountered only 15 years ago and frequently solved purely empirically by trial and error.

For their successful solution scientists, production engineers and designers have to work together. Their cooperation means the study and development of ideas and principles together with research into design problems, the results of which are in turn tested under actual production conditions. Only by such a combined operation will it be possible not only to keep pace with but also to contribute to the rapid developments which are at present in progress.

REFERENCES

[1] I. Nickols, "Batch Production Automation". *Journal of the Institution of Production Engineers*, November, 1958.

[2] F. Koenigsberger, "The Design of Automatic Machine Tools for Electronic Control". *Journal of the Institute of Production Engineers*, October, 1958.

drawn up. Let us now consider the remaining stages in a positional control system, deferring our discussion of continuous contour control for the moment. The basic problem is to cause the table, or other moving element, to move from its present location, defined by coordinates x_n, y_n, to its next location, x_{n+1}, y_{n+1}. The numerical values of the latter coordinates (x_{n+1}, y_{n+1}) define the "commanded position" i.e. the position to which we wish the table to move. If, at any instant, we measure the position of the table by means of its current coordinates (x, y) with respect to the chosen datum, then these coordinates may be said to define its "actual position."

REDUCING THE ERROR

The differences between x and x_{n+1}, and y and y_{n+1} are the resolved parts of the positional error along the x and y axes (see Fig. 2), and it is clearly our aim to reduce these to zero, i.e., to make the commanded and actual positions coincide. To achieve this, the table must be moved in a direction such that the positional error is reduced and this movement must be continued until the positional error is zero. This is, of course, only what a human operator does, but his ability to do it quickly and satisfactorily over a long period of time is limited by the human response time (of the order of 0·3 sec.) and the physiological fatigue to which he is subject.

If the functions discussed above are to be performed automatically, four elements are required for each axis to be controlled:

(1) an element which will accept the numerical information from the table of coordinates and convert it to a form more suited to automatic working;

(2) an element which will measure either the position of the moving element relative to a chosen datum or the displacement of the moving element from its most recent fixed location; this element should preferably express its information in the same form as the first element;

(3) a comparator which will accept, from elements 1 and 2, the information about the commanded and actual positions and deduce the difference between them, i.e., the positional error; and

(4) a power source which will drive the moving element in such a direction as to reduce the positional error; to do this the power source must be monitored by the output from the comparator, especially with regard to the sense of the positional error.

The basis on which elements 1 to 3 work may be mechanical, electrical, pneumatic or hydraulic, but, in practice, only electrical means provide sufficient flexibility and compactness for the purposes of machine tool control. The power source is usually an electric or hydraulic motor.

The principles discussed in the foregoing paragraphs are summarised in the block diagram of Fig. 3. The characteristic feature of this type of automatic control is the continuous feedback, to the comparator, of information about the position of the moving element. The various elements will now be briefly discussed, in turn.

TRANSFER ELEMENT

The function of the transfer element is to convert the numerical information of the table of coordinates into an electrical form suitable for feeding to the comparator. There are two problems to be resolved here; the first is how to convert, with as little human agency as possible, the numbers in the table of coordinates to some form in which they may be "read" or interpreted electrically and the second is to determine the electrical form in which the numbers will be fed to the comparator.

The manner in which the first problem is solved depends broadly on how many components are to be produced. If the number is very small, the control console can carry, at a convenient location, an array of ten-way or decade switches—one for each digit in the highest number to be transformed, due allowance being made for the number of significant digits to the right of the decimal point. The operator will then set the switches according to the required dimension. As an alternative to this, a telephone dial could be used and, since seven digits would suffice for virtually any engineering application, standard telephone accessories could be employed. With such devices as these, the operator is relieved of the mental fatigue of accurately positioning the table but is still required to be in constant attendance in order to set the switches or operate the telephone dial.

This suggests that some more permanent form of storing the numerical information is required for larger batches and the use of either punched cards or punched tape is attractive since standard card and tape readers are available. The operator is now only required at the beginning and end of each cycle of operations.

The second problem in transferring the numerical information was the choice of the electrical form in which the numbers would be expressed. There are two ways, broadly, of doing this—analogue and digital. In the former, the number is represented by some electrical quantity (normally a voltage, for convenience) to a chosen scale, e.g., 100 inches might be represented by 100 volts and so on *pro rata*. In the digital method, the number is represented by pulses, i.e., electrical signals of short duration and following each other at rapid but regular frequency, e.g., in a system where 0·001 inch was regarded as the finest sub-division required, it would be convenient to regard one pulse as representing 0·001 inch and a movement of 1·75 in would be commanded by 1,750 pulses. It could thus be said that an analogue system was position-conscious while a digital system was displacement-conscious. It is not possible in such a short review as this, to coment adequately on the advantages and disadvantages of analogue and digital methods but, fortunately, this is not a basic issue as far as the user is concerned except inasmuch as an analogue system is likely to be a little cheaper than a digital system although also somewhat less versatile.

POSITION MEASURING ELEMENT

In accordance with the normal use of the term, this is very frequently called the transducer and, having briefly mentioned analogue and digital methods, it is apposite to classify transducers initially into these two categories.

The chief analogue transducers are:—

(1) measuring bars, i.e., bars of non-magnetic material with magnetic inserts at regular and accurately spaced intervals, normal electrical pick-ups being used to locate the "magnetic centre-lines" of the inserts, and

(2) resolvers, which have a polyphase fixed winding and a single phase moving winding; the voltage output from such a device is uniquely characteristic of the position of the moving winding relative to the fixed winding. Such devices may have a single-pole winding or may be multi-polar. One example of the latter is the "Inductosyn" (a trade-name of Farrand Controls Incorporated, New York) which can be made for linear or rotary displacement;

(3) electrical potentiometers, which are probably the oldest transducers in general use but need much refinement for machine tool purposes;

(4) differential transformers—these are analogous to measuring bars, the magnetic inserts being replaced by a fixed electro-magnet.

The principal digital transducers are:—

(1) optical gratings (including diffraction gratings) in which the interruption of a beam of light by the grating creates a succession of pulses of electricity;

(2) digitising discs—these may be (*a*) electro-mechanical and produce the pulses by the relative movement of a contact arm and a series of contacts around a disc or (*b*) optical, in which case the electrical make and break action is replaced by alternate opaque and transparent sections on the disc.

The requirements of the transducer have been discussed in more detail elsewhere[1] but the difference between resolution and accuracy should be stressed as it often leads to misunderstanding. Resolution is the smallest displacement which can be detected by the transducer and is present in a perfect transducer; thus, it follows that the commanded position must be an integral multiple of the resolution. Accuracy expresses the extent to which any practical transducer is imperfect. It is frequently thought, and stated, that the resolution of the transducer must be smaller than the figure representing its accuracy; this is quite erroneous since the two parameters are unconnected. Indeed, in the "extended analogue range" technique, used by EMI Electronics Limited, the resolution is 100 inches while the accuracy must still be of the order of 0·001 in.

A discussion of the comparator element is too technical, electronically, to be attempted in a short, general review such as this.

POWER SOURCE

Only hydraulic and electric motors have achieved general acceptance in this field and it must be stressed that the power source forms part of the feedback loop i.e. the closed loop to the right hand side of Fig. 3. Consequently, if the performance of the automatic control system is to be adequate, it will be necessary to specify servo-motor performance not only by power but by such criteria as the width of the frequency response band.

Having discussed the general problem of positional control let us now consider the way in which a continuous contour control system will differ. The path taken between major points is now of importance so that we must not only specify the path which is to be followed but also be able to control the speed of relative movement at all times and to synchronise the motions along the various axes.

Specification of the path involves issuing to the control system enough information to define the path to be followed. This means the specification of the coordinates of points spaced at intervals of 0·0002 to 0·002 in say, depending on the accuracy required, the information being usually encoded on punched tape or magnetic tape.

To a specified accuracy, continuous control may be regarded as effected even if control is exerted discontinuously at a series of finite points provided these points are sufficiently close together. For normal accuracies, a spacing of 0·0002 to 0·002 in is required and, once this spacing is decided, coordinate values are required for each point; it should be quite clear that the comparator requires this information and that there is no way of avoiding this step. The stage at which manual effort may be saved is that of transferring the numerical information from the drawing to the control system. At one extreme, the coordinates of points at 0·0002 to 0·002 in spacing could be calculated using only a simple desk calculator. This was the method employed in the earliest numerically controlled machine tools but is obviously costly, time consuming and highly prone to errors. On the other hand, a digital computer could be programmed to perform these calculations and, although the computing cost might not show any startling reduction, there would undoubtedly be a big improvement in both the computing time and the reliability of the calculations.

IGNORANCE

As with any new conception, the principal obstacle to progress has been ignorance—ignorance of what this type of control is and what are its advantages and limitations. The purchaser is invariably well-experienced in matters of machine-tool usage but quite unaccustomed to the concepts (or specialised jargon) of control engineering and computer technology. The chief problems to be solved are undoubtedly to bridge the gap between the machine-tool user and the control specialist, and to accumulate much more data on the economic aspects of numerical control.

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Marketing

Growth of Aluminium Production in Australia

PARTLY coiled aluminium strip is to be supplied by the AUSTRALIAN ALUMINIUM Company, of New South Wales, to its subsidiary, ALUMINIUM FOILS (AUSTRALIA) Pty, when the parent company's £A3,500,000 expansion programme has been completed.

The Australian demand for extruded aluminium sections and tubing is reported to have increased sharply.

A feature of Australian Aluminium has been the high proportion of profits retained in the business during its 19 years of expansion. Internal funds and a £A3 million debenture raised in 1958 will meet the bills for the new plant and buildings.

Economic Attractions Take New Plant to Belgium

Within the European Common Market few industrial areas offer the advantages that can be found in Belgium. With unemployment removing doubts as to the labour supplies for new factories and with cheap interest rates, the Belgian Government has sought to interest developers by creating tax exemptions.

One company that has taken up these chances is the West German SIEMENS electrical group. It has purchased a 20 acre site near Bruges where it will employ some 350 workers.

A chemical plant is of course less sensitive to local labour situations. The United States chemical concerns, COLUMBIAN CARBON and CONTINENTAL CARBON, have set up an organisation in Milan which will build a combined plant for the production of carbon black. Two other American chemical firms, PHILLIPS PETROLEUM and G. L. CABOT, are to build carbon black plants at Ravenna in Italy. The combined output of the three will be some 55,000 tons a year, an indication that the companies' plan is to supply the Common Market with carbon black from Italy.

Growth of Engineering Output in Czechoslovakia

Although it may not be entirely possible to agree with the disparaging picture of the pre-war engineering industries of Czechoslovakia painted by the Prague magazine *Technical Digest*, there is no doubt of the immense increase in the contribution of engineering activities to the growth of the Czech economy.

Paying great attention to quality of workmanship, to methods of production and to research institutes and development departments, the Czechs have lifted the output of their engineering works to just short of six times that of 1948. The third five year plan, which involves new organisation and new new methods as much as greater output, should almost double present production by 1965.

This rise in the value of engineering's contribution took place while the total industrial output (1948 = 100) was increasing to an index of 333 in 1959. By 1965 the third plan should bring this index up to 550. The engineering industries' share of the 1965 total is expected to be 45 per cent, against 32·7 per cent last year and 18 per cent in 1948.

Special sections in which expansion has been most marked have been steam turbines and boilers, turbo-compressors and high-pressure fittings, machine tools and large marine diesel engines. As with other industrial exporters a feature of Czech manufactured exports has been the overseas sale of complete production plants. It is predicted that this can be expected to increase.

Scientific Instrument Show in Moscow

While the broadest possible picture of British industry is being presented in New York, a gallant array of optics, electronics, pneumatic systems and other techniques used by the instrument makers are on show in Moscow.

The exhibition, organised by the Scientific Instruments Manufacturers' Association of Great Britain, continues until 29 June.

EKCO ELECTRONICS are showing their latest nucleonic gauging techniques using radio-isotopes for establishing the level of fluids or slurries in closed tanks and pipelines. The company is also showing a fluid density gauge, utilising a radioactive source, to show changes in the density of material flowing along a pipe.

While this gauge has applications in industries as divergent as coal mining and tooth paste production, it is particularly useful in the petroleum industry for detecting the interface between different grades of oil travelling through a pipeline.

AIRMEC, whose electronic laboratory instruments are already in use in the USSR, are displaying signal generators of a variety of designs operating on many different wavebands.

Automatic Analysis

BAIRD AND TATLOCK have a particularly wide range of products indicating their complete service for equipping laboratories. They have made a special point of their Analmatic range of equipment for automation in chemical analysis.

An integrated range of instruments for sound and vibration measurement, analysis and recording is on the DAWE INSTRUMENTS stand. Stroboscopes and other industrial laboratory instruments are also among the company's exhibits.

EDWARDS HIGH VACUUM have on show their most recent vacuum pumps with various types of vacuum measuring equipment.

Mantle and jacket heating equipment and other laboratory accessories are among the ELECTROTHERMAL ENGINEERING exhibits. EMI ELECTRONICS are demonstrating a special system of closed circuit television and other electronic and nucleonic products.

FIRTH CLEVELAND INSTRUMENTS have sent tank gauges, flow meters, a cardiac stimulator and a miniature barograph.

GRIFFIN AND GEORGE are paying particular attention to automatic gas chromatography equipment and have included a representative collection of laboratory equipment.

Engineers' measuring tools and survey equipment are being shown by HILGER AND WATTS, who are also including emission spectrographs.

New designs and achievements in precision in densitometers and microdensitometers are contributed by JOYCE LOEBL.

From COURTNEY-PRATT is a high speed camera able to take up to 150,000 pictures a second in research and development work.

The list of well known names and the products they are showing in Moscow is long and the effort intense. QUICKFIT AND QUARE, the largest makers in the world of interchangeable glass laboratory equipment, are there. So are the SOLARTRON ELECTRONICS group, showing oscilloscopes, digital volt meters and advanced techniques in connection with power supply. One of the latest lines of development which Solartron is demonstrating in Moscow is that of equipment for engineers testing servo-systems.

The broad range of lectures given throughout the exhibition by members of SIMA covers the field from ultrasonic cleaning to digital techniques. Two special lectures are being delivered. By Professor R. V. Jones, of Aberdeen University, on "Some Developments of the Optical Lever," and Professor J. C. Tatlow, of Birmingham University, on "Recent Developments in the Field of Organic Fluorine Chemistry."

Money and Steel in Australia

Development of Australian industry and the future prospects of the Dominion have attracted £A500 million of foreign capital in the past five years. The Australian Federal treasurer, Mr. Holt, has now pointed out that last year his country raised more capital abroad than any other, despite the constant demand for investment funds. The total borrowed in 1959 was £A43 million.

One of the foundations of the Australian expansion has been the iron and steel industry. A good example is the AUSTRALIAN IRON AND STEEL Company, at Port Kembla, south of Sydney. In the last ten years this company alone has spent £A250 million on expanding its capacity and on housing and other building schemes. It produces almost 2,250,000 ingot tons of steel a year.

A new tinplate mill and cold strip mill will be in production before the end of next year.

The Shop Window in the Work Room

The display panel for almost every kind of small product is common enough in the shop window.

BRIDGES, the power tool manufacturers, have now brought the display one step further by offering their comprehensive home decorator set, based on the Bridges neonic drill, with a wall panel on which the components can be kept handily and neatly on the garage or home workshop wall.

If the dealer wishes, he can hang the wall panel in his shop window with more or less ready-made effect. For the owner of the set there are evident advantages in avoiding damage to parts and saving time by knowing exactly where they are.

The equipment that Bridges have now powered for the home decorator includes sanding discs, a special oscillating sander, a de-rusting wire cup brush, and not only a paint spray gun but a paint stirrer too.

Start on a Moscow Helicopter Terminal

A further indication of the advanced state of helicopter use in the Soviet Union is given by the announcement that work has begun on a Moscow helicopter station. The station will be the terminal from which helicopters will maintain services to each of the capital's air stations.

At the present stage of the city's development there are three airports. The helicopter services will be at 15 to 20 minutes intervals from the central terminal.

Traditional Slaughter Ritual in New Abattoir

A plant that combines the most modern European techniques with provision for traditional ritual slaughter is to be made by IWEL ENGINEERING Limited, of London, who specialise in meat handling plant.

The new abattoir is for the city of Kuwait, the Persian Gulf oil state. The £60,000 plant will be able to deal with 500 sheep and smaller numbers of cattle, goats or camels a day.

Yugoslav Yards Order Marine Boilers

Twelve auxiliary marine boilers have been ordered by BRODOIMPEKS, of Belgrade, for two Yugoslav shipyards, from COCHRAN & Company, of Dumfriesshire, Scotland.

The boilers, six oil-fired and six exhaust gas-fired boilers, will go into ships being built by the Yugoslavs for foreign owners. The contract is worth £56,000.

Delivery is due to begin before the end of the year. Before then Cochran's have hopes of another Yugoslav order—for three boilers.

Aircraft Engine Exports Pass the £300 Million Mark

British exports of engines for the world's aircraft are increasing at a rate only bettered by the improvement in the engines themselves.

The last month for which figures are available, April, reached a new record—£7,508,149—carrying the total worth of aero engines sent abroad since 1945 to £307,392,494. The value of engines exported in the first four months of the year was up 25 per cent on the same months of 1959, to £25,112,379 from £19·5 million. And the 1959 figure had been a quarter above that for the year before.

The jets and turbo-props of the airlines have reached the 1,000th plane either built or ordered with British engines. The current figures show that the Western airlines have 1,587 jets and turboprops flying or in the factory. ROLLS-ROYCE, BRISTOL SIDDELEY and NAPIER engines power all the 668 British turbo-airliners built or booked, all 82 French Caravelles, all the 166 Dutch Friendships and all the Canadian CL-44s, CC106s and 540s.

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REDUCING THE ERROR

The differences between x and x_{n+1}, and y and y_{n+1} are the resolved parts of the positional error along the x and y axes (see Fig. 2), and it is clearly our aim to reduce these to zero, i.e., to make the commanded and actual positions coincide. To achieve this, the table must be moved in a direction such that the positional error is reduced and this movement must be continued until the positional error is zero. This is, of course, only what a human operator does, but his ability to do it quickly and satisfactorily over a long period of time is limited by the human response time (of the order of 0·3 sec.) and the physiological fatigue to which he is subject.

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(2) an element which will measure either the position of the moving element relative to a chosen datum or the displacement of the moving element from its most recent fixed location; this element should preferably express its information in the same form as the first element;

(3) a comparator which will accept, from elements 1 and 2, the information about the commanded and actual positions and deduce the difference between them, i.e., the positional error; and

(4) a power source which will drive the moving element in such a direction as to reduce the positional error; to do this the power source must be monitored by the output from the comparator, especially with regard to the sense of the positional error.

The basis on which elements 1 to 3 work may be mechanical, electrical, pneumatic or hydraulic, but, in practice, only electrical means provide sufficient flexibility and compactness for the purposes of machine tool control. The power source is usually an electric or hydraulic motor.

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This suggests that some more permanent form of storing the numerical information is required for larger batches and the use of either punched cards or punched tape is attractive since standard card and tape readers are available. The operator is now only required at the beginning and end of each cycle of operations.

The second problem in transferring the numerical information was the choice of the electrical form in which the numbers would be expressed. There are two ways, broadly, of doing this—analogue and digital. In the former, the number is represented by some electrical quantity (normally a voltage, for convenience) to a chosen scale, e.g., 100 inches might be represented by 100 volts and so on *pro rata*. In the digital method, the number is represented by pulses, i.e., electrical signals of short duration and following each other at rapid but regular frequency, e.g., in a system where 0·001 inch was regarded as the finest sub-division required, it would be convenient to regard one pulse as representing 0·001 inch and a movement of 1·75 in would be commanded by 1,750 pulses. It could thus be said that an analogue system was position-conscious while a digital system was displacement-conscious. It is not possible in such a short review as this, to coment adequately on the advantages and disadvantages of analogue and digital methods but, fortunately, this is not a basic issue as far as the user is concerned except inasmuch as an analogue system is likely to be a little cheaper than a digital system although also somewhat less versatile.

POSITION MEASURING ELEMENT

In accordance with the normal use of the term, this is very frequently called the transducer and, having briefly mentioned analogue and digital methods, it is apposite to classify transducers initially into these two categories.

The chief analogue transducers are:—

(1) measuring bars, i.e., bars of non-magnetic material with magnetic inserts at regular and accurately spaced intervals, normal electrical pick-ups being used to locate the "magnetic centre-lines" of the inserts, and

(2) resolvers, which have a polyphase fixed winding and a single phase moving winding; the voltage output from such a device is uniquely characteristic of the position of the moving winding relative to the fixed winding. Such devices may have a single-pole winding or may be multi-polar. One example of the latter is the "Inductosyn" (a trade-name of Farrand Controls Incorporated, New York) which can be made for linear or rotary displacement;

(3) electrical potentiometers, which are probably the oldest transducers in general use but need much refinement for machine tool purposes;

(4) differential transformers—these are analogous to measuring bars, the magnetic inserts being replaced by a fixed electro-magnet.

The principal digital transducers are:—

(1) optical gratings (including diffraction gratings) in which the interruption of a beam of light by the grating creates a succession of pulses of electricity;

(2) digitising discs—these may be (*a*) electro-mechanical and produce the pulses by the relative movement of a contact arm and a series of contacts around a disc or (*b*) optical, in which case the electrical make and break action is replaced by alternate opaque and transparent sections on the disc.

The requirements of the transducer have been discussed in more detail elsewhere[1] but the difference between resolution and accuracy should be stressed as it often leads to misunderstanding. Resolution is the smallest displacement which can be detected by the transducer and is present in a perfect transducer; thus, it follows that the commanded position must be an integral multiple of the resolution. Accuracy expresses the extent to which any practical transducer is imperfect. It is frequently thought, and stated, that the resolution of the transducer must be smaller than the figure representing its accuracy; this is quite erroneous since the two parameters are unconnected. Indeed, in the "extended analogue range" technique, used by EMI Electronics Limited, the resolution is 100 inches while the accuracy must still be of the order of 0·001 in.

A discussion of the comparator element is too technical, electronically, to be attempted in a short, general review such as this.

POWER SOURCE

Only hydraulic and electric motors have achieved general acceptance in this field and it must be stressed that the power source forms part of the feedback loop i.e. the closed loop to the right hand side of Fig. 3. Consequently, if the performance of the automatic control system is to be adequate, it will be necessary to specify servo-motor performance not only by power but by such criteria as the width of the frequency response band.

Having discussed the general problem of positional control let us now consider the way in which a continuous contour control system will differ. The path taken between major points is now of importance so that we must not only specify the path which is to be followed but also be able to control the speed of relative movement at all times and to synchronise the motions along the various axes.

Specification of the path involves issuing to the control system enough information to define the path to be followed. This means the specification of the coordinates of points spaced at intervals of 0·0002 to 0·002 in say, depending on the accuracy required, the information being usually encoded on punched tape or magnetic tape.

To a specified accuracy, continuous control may be regarded as effected even if control is exerted discontinuously at a series of finite points provided these points are sufficiently close together. For normal accuracies, a spacing of 0·0002 to 0·002 in is required and, once this spacing is decided, coordinate values are required for each point; it should be quite clear that the comparator requires this information and that there is no way of avoiding this step. The stage at which manual effort may be saved is that of transferring the numerical information from the drawing to the control system. At one extreme, the coordinates of points at 0·0002 to 0·002 in spacing could be calculated using only a simple desk calculator. This was the method employed in the earliest numerically controlled machine tools but is obviously costly, time consuming and highly prone to errors. On the other hand, a digital computer could be programmed to perform these calculations and, although the computing cost might not show any startling reduction, there would undoubtedly be a big improvement in both the computing time and the reliability of the calculations.

IGNORANCE

As with any new conception, the principal obstacle to progress has been ignorance—ignorance of what this type of control is and what are its advantages and limitations. The purchaser is invariably well-experienced in matters of machine-tool usage but quite unaccustomed to the concepts (or specialised jargon) of control engineering and computer technology. The chief problems to be solved are undoubtedly to bridge the gap between the machine-tool user and the control specialist, and to accumulate much more data on the economic aspects of numerical control.

REFERENCE

[1] R. C. Brewer, *The Numerical Control of Machine Tools*, 2nd Edition. The Engineers' Digest Ltd., London.

Marketing

Growth of Aluminium Production in Australia

PARTLY coiled aluminium strip is to be supplied by the AUSTRALIAN ALUMINIUM Company, of New South Wales, to its subsidiary, ALUMINIUM FOILS (AUSTRALIA) Pty. when the parent company's £A3,500,000 expansion programme has been completed.

The Australian demand for extruded aluminium sections and tubing is reported to have increased sharply.

A feature of Australian Aluminium has been the high proportion of profits retained in the business during its 19 years of expansion. Internal funds and a £A3 million debenture raised in 1958 will meet the bills for the new plant and buildings.

Economic Attractions Take New Plant to Belgium

Within the European Common Market few industrial areas offer the advantages that can be found in Belgium. With unemployment removing doubts as to the labour supplies for new factories and with cheap interest rates, the Belgian Government has sought to interest developers by creating tax exemptions.

One company that has taken up these chances is the West German SIEMENS electrical group. It has purchased a 20 acre site near Bruges where it will employ some 350 workers.

A chemical plant is of course less sensitive to local labour situations. The United States chemical concerns, COLUMBIAN CARBON and CONTINENTAL CARBON, have set up an organisation in Milan which will build a combined plant for the production of carbon black. Two other American chemical firms, PHILLIPS PETROLEUM and G. L. CABOT, are to build carbon black plants at Ravenna in Italy. The combined output of the three will be some 55,000 tons a year, an indication that the companies' plan is to supply the Common Market with carbon black from Italy.

Growth of Engineering Output in Czechoslovakia

Although it may not be entirely possible to agree with the disparaging picture of the pre-war engineering industries of Czechoslovakia painted by the Prague magazine *Technical Digest*, there is no doubt of the immense increase in the contribution of engineering activities to the growth of the Czech economy.

Paying great attention to quality of workmanship, to methods of production and to research institutes and development departments, the Czechs have lifted the output of their engineering works to just short of six times that of 1948. The third five year plan, which involves new organisation and new new methods as much as greater output, should almost double present production by 1965.

This rise in the value of engineering's contribution took place while the total industrial output (1948 = 100) was increasing to an index of 333 in 1959. By 1965 the third plan should bring this index up to 550. The engineering industries' share of the 1965 total is expected to be 45 per cent, against 32·7 per cent last year and 18 per cent in 1948.

Special sections in which expansion has been most marked have been steam turbines and boilers, turbo-compressors and high-pressure fittings, machine tools and large marine diesel engines. As with other industrial exporters a feature of Czech manufactured exports has been the overseas sale of complete production plants. It is predicted that this can be expected to increase.

Scientific Instrument Show in Moscow

While the broadest possible picture of British industry is being presented in New York, a gallant array of optics, electronics, pneumatic systems and other techniques used by the instrument makers are on show in Moscow.

The exhibition, organised by the Scientific Instruments Manufacturers' Association of Great Britain, continues until 29 June.

EKCO ELECTRONICS are showing their latest nucleonic gauging techniques using radio-isotopes for establishing the level of fluids or slurries in closed tanks and pipelines. The company is also showing a fluid density gauge, utilising a radioactive source, to show changes in the density of material flowing along a pipe.

While this gauge has applications in industries as divergent as coal mining and tooth paste production, it is particularly useful in the petroleum industry for detecting the interface between different grades of oil travelling through a pipeline.

AIRMEC, whose electronic laboratory instruments are already in use in the USSR, are displaying signal generators of a variety of designs operating on many different wavebands.

Automatic Analysis

BAIRD AND TATLOCK have a particularly wide range of products indicating their complete service for equipping laboratories. They have made a special point of their Analmatic range of equipment for automation in chemical analysis.

An integrated range of instruments for sound and vibration measurement, analysis and recording is on the DAWE INSTRUMENTS stand. Stroboscopes and other industrial laboratory instruments are also among the company's exhibits.

EDWARDS HIGH VACUUM have on show their most recent vacuum pumps with various types of vacuum measuring equipment.

Mantle and jacket heating equipment and other laboratory accessories are among the ELECTROTHERMAL ENGINEERING exhibits. EMI ELECTRONICS are demonstrating a special system of closed circuit television and other electronic and nucleonic products.

FIRTH CLEVELAND INSTRUMENTS have sent tank gauges, flow meters, a cardiac stimulator and a miniature barograph.

GRIFFIN AND GEORGE are paying particular attention to automatic gas chromatography equipment and have included a representative collection of laboratory equipment.

Engineers' measuring tools and survey equipment are being shown by HILGER AND WATTS, who are also including emission spectrographs.

New designs and achievements in precision in densitometers and microdensitometers are contributed by JOYCE LOEBL.

From COURTNEY-PRATT is a high speed camera able to take up to 150,000 pictures a second in research and development work.

The list of well known names and the products they are showing in Moscow is long and the effort intense. QUICKFIT AND QUARE, the largest makers in the world of interchangeable glass laboratory equipment, are there. So are the SOLARTRON ELECTRONICS group, showing oscilloscopes, digital volt meters and advanced techniques in connection with power supply. One of the latest lines of development which Solartron is demonstrating in Moscow is that of equipment for engineers testing servo-systems.

The broad range of lectures given throughout the exhibition by members of SIMA covers the field from ultrasonic cleaning to digital techniques. Two special lectures are being delivered. By Professor R. V. Jones, of Aberdeen University, on "Some Developments of the Optical Lever," and Professor J. C. Tatlow, of Birmingham University, on "Recent Developments in the Field of Organic Fluorine Chemistry."

Money and Steel in Australia

Development of Australian industry and the future prospects of the Dominion have attracted £A500 million of foreign capital in the past five years. The Australian Federal treasurer, Mr. Holt, has now pointed out that last year his country raised more capital abroad than any other, despite the constant demand for investment funds. The total borrowed in 1959 was £A43 million.

One of the foundations of the Australian expansion has been the iron and steel industry. A good example is the AUSTRALIAN IRON AND STEEL Company, at Port Kembla, south of Sydney. In the last ten years this company alone has spent £A250 million on expanding its capacity and on housing and other building schemes. It produces almost 2,250,000 ingot tons of steel a year.

A new tinplate mill and cold strip mill will be in production before the end of next year.

The Shop Window in the Work Room

The display panel for almost every kind of small product is common enough in the shop window.

BRIDGES, the power tool manufacturers, have now brought the display one step further by offering their comprehensive home decorator set, based on the Bridges neonic drill, with a wall panel on which the components can be kept handily and neatly on the garage or home workshop wall.

If the dealer wishes, he can hang the wall panel in his shop window with more or less ready-made effect. For the owner of the set there are evident advantages in avoiding damage to parts and saving time by knowing exactly where they are.

The equipment that Bridges have now powered for the home decorator includes sanding discs, a special oscillating sander, a de-rusting wire cup brush, and not only a paint spray gun but a paint stirrer too.

Start on a Moscow Helicopter Terminal

A further indication of the advanced state of helicopter use in the Soviet Union is given by the announcement that work has begun on a Moscow helicopter station. The station will be the terminal from which helicopters will maintain services to each of the capital's air stations.

At the present stage of the city's development there are three airports. The helicopter services will be at 15 to 20 minutes intervals from the central terminal.

Traditional Slaughter Ritual in New Abattoir

A plant that combines the most modern European techniques with provision for traditional ritual slaughter is to be made by IWEL ENGINEERING Limited, of London, who specialise in meat handling plant.

The new abattoir is for the city of Kuwait, the Persian Gulf oil state. The £60,000 plant will be able to deal with 500 sheep and smaller numbers of cattle, goats or camels a day.

Yugoslav Yards Order Marine Boilers

Twelve auxiliary marine boilers have been ordered by BRODOIMPEKS, of Belgrade, for two Yugoslav shipyards, from COCHRAN & Company, of Dumfriesshire, Scotland.

The boilers, six oil-fired and six exhaust gas-fired boilers, will go into ships being built by the Yugoslavs for foreign owners. The contract is worth £56,000.

Delivery is due to begin before the end of the year. Before then Cochran's have hopes of another Yugoslav order—for three boilers.

Aircraft Engine Exports Pass the £300 Million Mark

British exports of engines for the world's aircraft are increasing at a rate only bettered by the improvement in the engines themselves.

The last month for which figures are available, April, reached a new record—£7,508,149—carrying the total worth of aero engines sent abroad since 1945 to £307,392,494. The value of engines exported in the first four months of the year was up 25 per cent on the same months of 1959, to £25,112,379 from £19·5 million. And the 1959 figure had been a quarter above that for the year before.

The jets and turbo-props of the airlines have reached the 1,000th plane either built or ordered with British engines. The current figures show that the Western airlines have 1,587 jets and turboprops flying or in the factory. ROLLS-ROYCE, BRISTOL SIDDELEY and NAPIER engines power all the 668 British turbo-airliners built or booked, all 82 French Caravelles, all the 166 Dutch Friendships and all the Canadian CL-44s, CC106s and 540s.

Combined Recording of Load and Strain

Comparing deflection with load for a given specimen under tension, compression or simple bending is an everyday laboratory problem. The autographic recorder plots a continuous curve during a test, obviating the necessity for constant vigilance.

By E. Spencer, M.Sc.Tech., Manchester College of Science and Technology

IN TRIAXIAL compression tests on soil specimens, the cylindrical specimen is subjected to both an equal-all-round pressure which remains constant, and an axial stress which is increased until failure takes place. The axial load is normally measured by means of a proving ring; the deflection of the ring is indicated on a dial gauge and the load corresponding to the dial gauge readings can be obtained by referring to a calibration chart. The deflection of the specimen is measured by means of a second dial gauge. Two dial gauges must therefore be read at intervals and this calls for the constant or periodic attention of an observer, depending upon the rate of strain being used. In certain types of test, a very low rate of strain may be used; in this case the test may continue for several days and taking the observations then becomes something of a problem. The autographic recording device described in this article was designed by the author and used for soil triaxial compression tests. It produces a record, in the form of a graph, of the axial load on the specimen and the resulting deflection. When this device is used the services of an observer are not required, apart from occasional visits to check the progress of the test.

OPERATION

The recorder mechanism is shown in Fig. 1; the load is applied to the top of the cylindrical case and measured by means of the internal tension spring. One end of the spring is attached to the lower end of the case, while the upper end of the spring is attached to a ½ in diameter steel rod, which is co-axial with the spring and in indirect contact with the specimen. As the load increases, the spring stretches and a pinion at the top of the rod runs up a rack attached to the inside of the case at the upper end. The pinion spindle protrudes through both sides of the case and carries at one end a 10 in diameter white perspex chart plate with a roughened surface, and at the other end a counterbalance weight. Extension of the spring under load causes the chart plate to rotate, and the angle through which it turns is thus proportional to the load on the spring.

The lower end of the steel rod rests on the top of a plunger which enters the cell containing the specimen. The deflection of the specimen is measured by means of an L-shaped tracing arm which is carried on a pivot at the lower end of the rod. The shorter leg of the tracing arm rests on a fixed lug on top of the cell containing the specimen, and the longer end of the arm carries a pencil which rests against the chart plate. As the specimen deflects, the plunger and the rod descend, this causes the tracing arm to describe an arc on the chart plate. The length of this arc is thus a measure of the deflection of the specimen.

Fig. 2 is a photograph of the device taken during a triaxial compression test on a soil specimen. The trace drawn by the pencil is clearly visible on the chart plate.

At the end of the test, the tracing arm is swung out of the way and a circular transparent mask, as shown in Fig. 3, is fitted on to the spindle of the chart plate. The mask is rotated until a zero line intersects the beginning of the trace and the deflection of the specimen, and the load on it at any stage of the test can then be read off from lines inscribed on the mask. These comprise two sets of lines; a series of concentric circles indicating the deflection, and a set of radiating arcs indicating load. The circles and arcs were constructed from information obtained in a calibration test.

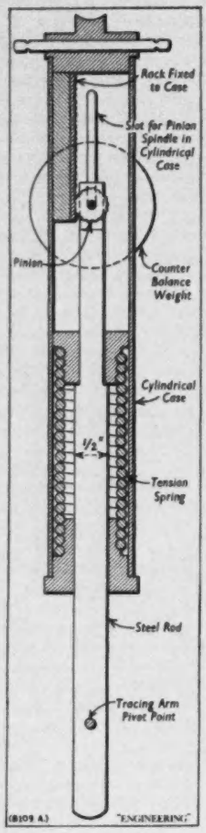


Fig. 1 Sectional diagram of recorder mechanism.

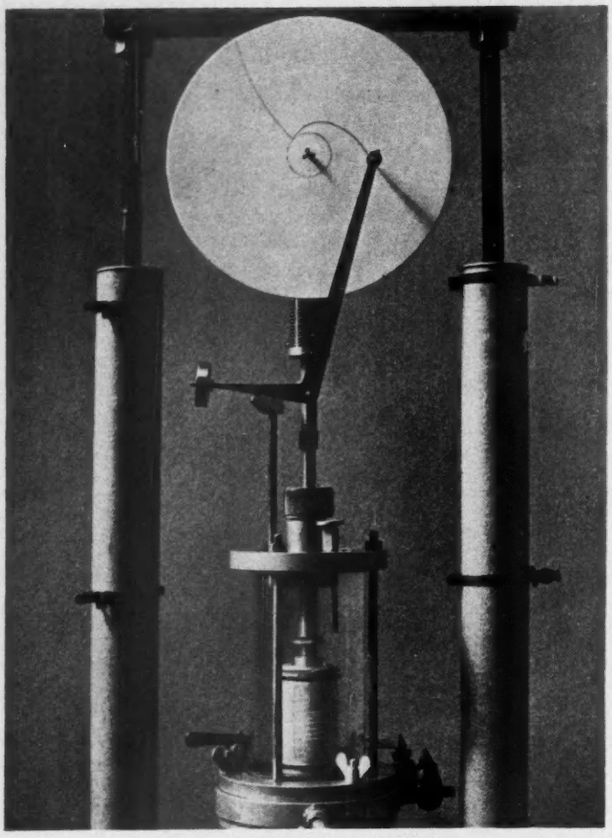


Fig. 2 View of equipment during a triaxial test on a soil specimen. The trace on the chart is cleary visible.

The maximum deflection which can be recorded by this instrument is 0·8 in and the maximum load is 150 lb. This maximum load corresponds to an extension of the spring of 2 in.

CALIBRATION TEST

Though it would, of course, have been possible to calibrate this instrument on a theoretical basis, it was considered preferable to carry out special calibration tests. These closely resembled triaxial compression tests but a calibrated compression spring was used instead of a soil specimen. This spring had roughly the same dimensions as a soil specimen, and at the maximum load (150 lb) its deflection was about 0·8 in. During the calibration tests, the deflection of the compression spring was measured by a dial gauge reading to 1/10,000th of an inch.

Though all the required information could have been obtained from a single test it was found more convenient to carry out two tests. The first was used to obtain the deflection calibration, and the second to measure the load. In the first test, as deflections of 0·1 in, 0·2 in, 0·3 in, etc., were indicated on the dial gauge, marks were made on the trace which the pencil was making on the chart plate. Subsequently the distances of these marks from the centre of the chart plate were measured, which gave the radii of the concentric circles to be inscribed on the transparent mask to show the deflection of the specimen. In the second test, marks were made on the pencil trace at points where the deflection of the compression spring corresponded to loads of 10, 20, 30 lb and so on up to a maximum of 150 lb. These marks indicated the angle through which the chart plate had rotated for each of the loads, thus giving the angles between the circular radiating arcs to be inscribed on the mask to indicate the load on the specimen. The radius of these arcs is equal to the radius of the tracing arm.

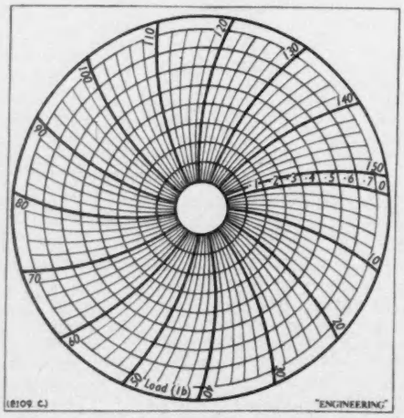


Fig. 3 Transparent mask showing markings.

Pocket Size Electric Motor

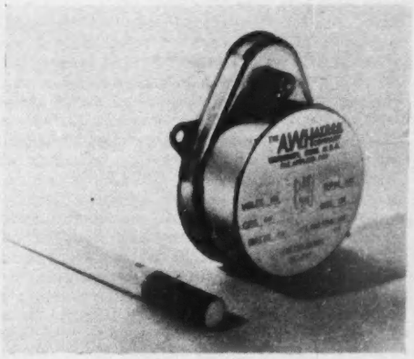
A miniaturised motor, no longer than a cigarette filter, and designed to allow the direction of rotation to be established by electrical control alone, is the latest addition to the line of synchronous a.c. timing motors manufactured by the A. W. Haydon Company, 232 North Elm Street, Waterbury, Connecticut, USA.

Designated as the Series 42,100 Commercial 60 cycle a.c. timing motor, this 5 oz device was designed for applications where reliability, performance and space are of prime consideration. Currently being used in many applications, including the company's own commercial programmers, long-life repeat cycle timers, time delay relays, elapsed time indicators, stop clocks, and other custom designed timers, the motor provides extremely fast starting and stopping, eliminating prestarting and clutching in many applications.

Length of these motors is only $\frac{7}{8}$ in, making them the shortest motors available, the company claims, with no sacrifice in running torque, nominally specified as 30 ounce-inches. Available in voltages ranging from 6 to 230 volts at 20 micro-amps maximum, the unit's rotor speed is 300 r.p.m. with output speeds of 300 r.p.m. down to $\frac{1}{6}$ r.p.h. Direction of rotation is optional and established solely by electrical control, thereby eliminating the need for noisy and troublesome mechanical devices with limited life. Maximum temperature rise is only 40° C, while power input is stated to be 2·5 watts maximum. (All specifications are stated for an input frequency of 60 cycles; 25 and 50 cycle versions are also available.)

The manufacturer states that two basic gear trains are available to meet various requirements, with output torque independent of gear train material. The standard gear train has brass wheels and steel pinions, while the optional hard steel gear train will carry up to three times normal load, thereby obtaining greater usable torque. The standard shaft is $\frac{1}{8}$ in diameter by $\frac{3}{8}$ in long. A large number of variations to the standard shaft are offered, and special shafts can be supplied on demand.

Additional applications for this lightweight motor are in chart drives, control equipment, and any application requiring an accurate time base or source of rotary timing power.



Series 42,100 miniaturised timing motor $\frac{7}{8}$ in long, compared with a cigarette filter tip.

Further information on the new line of Series 42,100 motors may be obtained by writing directly to the company.

Lightweight Headsets for Conversing in Aircraft

Improved "Airlite" headsets are now on the market to facilitate pilot-to-ground or pilot-to-passenger intercommunication in modern aircraft, where high noise levels are frequently encountered. The illustration shows one being used by the pilot of a helicopter to converse with his passengers against the noisy background. They are also very suitable for use in high-flying jet aircraft, since they permit donning an oxygen mask without taking off the headset, and in fact provide the platform for attaching the mask. Their extreme lightness also contributes to the comfort of the wearer, the total weight complete with boom microphone, 6 ft of down lead and plug being only 15 oz.

Airlite headset being used by the pilot of a Westland Widgeon helicopter.

The earpads are of oval-shaped plastic, either liquid filled or plain plastic foam covered to suit the application. Liquid filled pads ensure maximum sound attenuation for use in noisy aircraft, while the foam pads provide only slight sound attenuation for, say, ground application. The boom microphone provides a choice between a differential noise cancelling or a plain electromagnetic type, again to suit the application. Normal impedance is 300 ohms. Carbon microphones are available to special order. The movement of the boom carrying the microphone is controlled in all planes by a special plastic boom clutch. This ensures smooth movement and is easily adjusted for tension. The microphone wire is entirely enclosed and passes directly into the telephone housing. The telephones themselves are high efficiency lightweight units of 300 ohms impedance each, fully tropicalised. They are mounted in plastic mouldings with a broad flange for earpad mounting, and are attached to the headband by friction plates. The headband consists of cadmium plated lightweight spring steel wire with elongated end loops for telephone housing adjustment. A foam plastic headpad is also attached.

The electrical wiring consists of best-quality tinsel pvc-covered lead, adequately screened on the microphone circuit. A terminal connection board is incorporated in one telephone housing to facilitate servicing. The connecting plug is normally a 4-way NATO jack plug (AM ref. 671) but alternatives are available.

Airlite headsets are supplied by Airmed Limited of Edinburgh Way, Harlow, Essex. They are now fitted as standard equipment in the aircraft of several independent airlines and charter companies, including BOAC Britannia, Comet 4 and Boeing 707 fleets, and Executair's helicopters.

Design facilities are available for the benefit of customers with special requirements, including a colour matching service.

Capacitance Relay for Level Detection

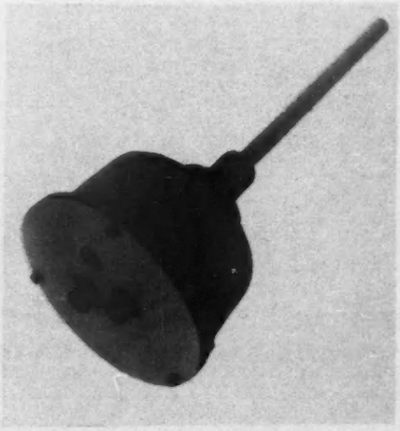
A new transistorised capacitance relay is now on the market; it operates on the well established capacity method and is suitable for level detection of liquids or granular solids. Two versions are available: the direct mounting type has the probe integral with the relay, and the wall mounting type has the probe separate from the relay but connected by a coaxial cable.

The instrument housing of both types is weatherproofed and of aluminium alloy construction. Since adequate protection is given to the transistors and printed circuit, the equipment is suitable for exposed situations. Several types of probe are available to fit into the standard casing, to cover a wide range of applications. These probes can be easily interchanged if so desired. Both versions of the capacitance relay are constructed to withstand vibration, although in severe cases it is recommended that the separately mounted unit is used, with the electronic unit isolated from the source of vibration.

An electrical supply of 110 to 120 volts or 200 to 240 volts a.c. single phase 50 cycles per second is required to operate the unit. The power consumption excluding external alarm devices is approximately 3 watts.

The sensitivity of the instrument is better than 0·1 pF under all conditions. Long term stability does not exceed 0·15 pF from the mean value over six months, with the same supply voltage and temperature. Provision is incorporated for increasing the relay differential from the minimum value of 0·05 pF to any required value between 1·0 pF and 25 pF. The relay has sealed triple pole changeover contacts capable of switching 5 amps at 250 volts a.c.

The new relay is available from Bailey Meters and Controls Limited, Purley Way, Croydon, Surrey, and is a recent addition to their range of electronic equipment.

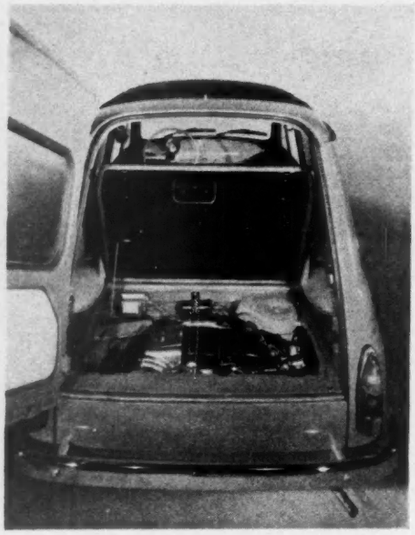


Exterior view of transistorised capacitance relay.

Fiat 500 Giardiniera

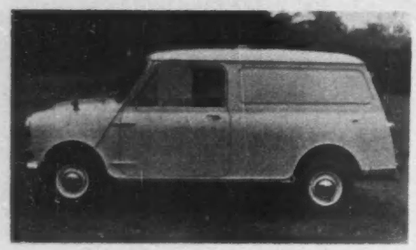
The new station wagon version of the rear-engined Fiat 500 has an all-steel unit body-chassis with a wheelbase nearly 4 in longer than the coupé, to give seating space for four adults. The rear seats fold away and, to permit a low floor with easy loading of baggage through a good-sized rear door the two-cylinder air-cooled engine has been laid on its side. Cooling air reaches it through grilles which are sited to minimise dust collection in the rear quarter panels, behind the windows, and passes down through ducts in the corners of the body. Engine size has been raised from 479 to 499 c.c. by an increase of 1·4 mm on the cylinder bores (67·4 by 70 mm), producing a small increase in installed power (17·5 b.h.p.) and torque. Gross power is quoted unchanged at 21·5 b.h.p. and final drive ratio remains 5·125 to 1.

The under-floor position of the engine has called for re-arrangement of the auxiliaries. Crankcase and sump have been redesigned and a shaft normal to the cylinder axes drives oil pump and distributor. A belt drive from the usual crankshaft pulley with centrifugal oil filter drives cooling fan and dynamo placed to the left of the engine. Pipes from exhaust ports to silencer are very short and the latter will presumably operate at fairly high temperatures. Engine mountings appear similar to those for the vertical unit. When the hinged floor panel is lifted, there is good access to plugs, distributor, starter and carburettor. The car has drop windows in the doors and sliding panes behind them. A folding roof panel is standard. Kerb weight is given as 1,224 lb and maximum speed as 60 m.p.h.



In the Giardiniera station wagon the engine is laid on its side below the floor.

Mini-Minor Van with 560 lb Payload



The BMC is now producing a light van derived from the Austin and Morris 850 Mini-Minor. Mechanical parts and the sub frames on which they are mounted are almost identical with those of the saloon version, but the van body shell is longer, giving an extra 4 in on the wheelbase, and an extra 6 in of rear overhang, thereby increasing overall length by 10 in. The van weighs 1,345 lb dry and has 46½ cu. ft of space behind the seats, with a further 12 cu. ft beside the driver which can be made available by removing the second seat. Carrying capacity is two people, plus 560 lb payload.

No particular modifications to power unit or transmission have been made for the commercial version, but the mix of the rubber in the suspension units has been varied to cope with the greater loads. Later, this shell will form the basis of a station wagon body, and an open pick-up truck will also be added to the range.

Four to Five Seater Peugeot 404

The long-heralded new Peugeot turned out to be not a successor to the recently abandoned 1·3 litre 203, as some people had predicted, but a new 1·6 litre four-five seater, more powerful and slightly more expensive than the 403, which continues in production in its normal and newly introduced 1,300 c.c. economy forms.

The new car has a 1·6 litre over-square engine canted over on its side at 45° and offers body space almost equal to the 403 but is smaller and lower built. Body styling, for which Pinin Farina acted as consultant, is a synthesis of the work he has already done for BMC and Lancia, and shows no significant departures. It is thus appropriate to the solid conservative tradition of Peugeot who have founded their reputation on excellent quality and durability of their cars rather than on styling or technical innovations.

The 404 does depart from previous Peugeot practice in many ways. The canted engine is said to drop the centre of gravity of the power unit by over 2 in. It also permits a low bonnet line, but full advantage has not been taken of this as a large carburettor air cleaner is placed above the engine. The gearbox is a conventional unit with four speeds, all synchronised, top being direct, whereas the 403 has direct drive on third and a geared up top. However, with an axle ratio of 4·2 to 1 the 404 does 17·67 m.p.h. per 1,000 r.p.m. on its direct top, against 16·71 m.p.h. for the 403 which uses a geared up top in conjunction with an axle ratio of 5·75 to 1.

Transmission is by torque tube and worm final drive as on previous models, with suspension by coil springs and non-concentric telescopic dampers. Front suspension is however, a departure for Peugeot, utilising a long suspension trut which also acts as steering kingpin in a similar way to the Macpherson system on the British Fords, and the type used on the French Vespa. The outer casing of the damper acts as the kingpin and has the hub attached to its lower end. The upper pivot is a ball bearing in the cup at the lower end of the concentric coil spring. Apparently the whole assembly is centered by the damper piston rod which is anchored in a cup in a bonded rubber mounting high under the front wing. The lower end of the damper carries a ball joint which is mounted in the outer end of a transverse track control arm, a light diagonal tie running forward to an anchorage on the car frame to take braking forces. The four-door body is a unit structure in steel.

The engine, following Peugeot practice, is a four-cylinder unit with cast iron block and crankcase, and inclined valves in hemispherical combustion chambers operated by angled push-rods and opposed rockers. The valves are set at a smaller included angle than previously, in a modified combustion chamber said to promote more turbulence, and the crankcase descends further below the crankshaft centre line. It is an over-square unit with bore and stroke of 84 × 73 mm (1,616 c.c. giving 72 b.h.p. SAE at 5,400 r.p.m.). Maximum torque of 93·7 lb-ft is produced at 2,250 r.p.m. The carburettor is mounted on an external water-heated manifold.

The instrument panel recalls that of the DS 19 Citroen, with large fresh air ducts at each side, the direction and volume of flow being controllable by shutters.

Drums of 10 in diameter, approximately 2 in wide, are used on the brakes with two leading shoes at the front. Steering is by rack and pinion. Dimensions: wheelbase 105·3 in; track, front 52·95 in, rear 50·38 in; height 57·1 in; tyres 165 × 380.

The 1·6 litre Peugeot 404 with seating for four or five.

Radar is Threatening to Get in the Way

Radar and microwave-communications have each become an integral part of the modern way of life. The possibility of these two services becoming incompatible is now causing concern.

DURING the past decade, microwave links have become increasingly useful in the transmission of television and telephone signals and in various applications such as automatic switch protection. However, at the same time, there has been a mushrooming growth of radar systems for both military and civil applications. These two services, radar and microwave-communications, are now beginning to show signs of incompatibility.

The extent and degree of this incompatibility has been the subject of a broad investigation carried out in the United States by the Bell Telephone Laboratories.

It is true that radar systems are assigned frequencies outside the bands given to the common-carrier microwave systems. However, the high power of many radar transmitters, along with their wide dispersion gives rise to an increasing likelihood of interference with all types of microwave communication signals.

SPURIOUS EMISSIONS

Such interference does not necessarily come from the direct, powerful radar pulses, in fact, it is more likely to come from harmonics and spurious emissions. Interference may also arise from maladjustments of a radar, causing occasional full power pulses to be transmitted in the frequency bands assigned to radio communications.

Radar interference appears as a rough buzzing noise in telephone circuits; as moving, almost randomly located white dashes in a television picture; and as errors in data signals. Such interference is likely to be of a fleeting nature, depending on the hours of operation of the radar, and on how rapidly the radar scans its assigned sector. Interference with ordinary telephone conversations and with television viewing may only be a nuisance, but with circuits carrying data signals, such interference cannot be tolerated.

TABLE.—*Radar Interference Effects, Including 30 db Fading Allowance*

Radar's location with respect to communications receiver	Maximum tolerable effective radiated power of radar spurious output in dbm*	
	Television channels	Telephone channels
Anywhere beyond a few hundred yards	−25	−10
On the same site, receiving antenna pointed away from radar	+15	+30
Anywhere, except along 1-mile corridor centred on microwave route	+25	+40

* db referred to 1 MW in 600 ohms.

Experiments carried out by the Bell Telephone Laboratories have simulated an interference condition by injecting a pulsed microwave signal (representing the radar interference) into a receiver with a signal from a microwave transmitter (representing the desired transmission). By using an assembly of waveguide couplers and variable attenuators, engineers have been able to adjust independently the strength of each of these signals at the receiver input. They have found that as the peak value of the interference signal approaches the peak value of the desired signal, the interfering noise in telephone circuits rises very rapidly.

The noise is negligible when the ratio of peak signal to peak interference at the receiver input is more than 5 decibels (db). But it is intolerable when the ratio is unity (0 db) or less.

Similar tests with television signals have indicated that they are more sensitive to radar pulse interference than are telephone signals. Here, it appears that the ratio of peak signal to peak interference must be more than 15 db in order to avoid degraded television pictures.

For a typical Bell System microwave receiver, transmission engineers have made estimates of the maximum tolerable interference power that may be radiated from a radar without causing interference. A tabulation of these estimates is given (in the table) for various relative locations of the radar and receiver. Since some radars have spurious outputs of effective radiated power as high as 5 megawatts (+ 97 dbm) steps must be taken either to reduce the spurious emission or to keep it from reaching the microwave receiver input. Each course of action has a number of practical limitations.

American engineers have been cognisant of the interference problem for some time and have taken three courses of action simultaneously. First they have discussed the problem with representatives of the armed services, the manufacturers of radar equipment, aviation and communications authorities, and as meteorologists, all of whom have an interest in microwave communications. The second course of action has been a series of laboratory experiments to determine how strong an interfering radar signal may be without causing excessive interference. Finally, engineers have measured radiation from operational radars in the field to determine the frequency and power of unwanted components of emission. This three-pronged approach has covered the problem comprehensively and has led to some interesting results.

To investigate radiation from radars in the field, Bell Laboratory engineers have set up a mobile laboratory. The equipment is taken to the test site and set up so that there are no obstructions and no reflecting areas in or near the transmission path. Engineers then erect a receiving horn and aim it toward the radar by optical sighting. The test engineer then tunes in the main radar signal on his receiver and directs the radar operator by telephone to aim the radar beam precisely on the receiving horn. The radar signal can then be observed on a signal strength meter and on an oscilloscope (shown in the illustrations).

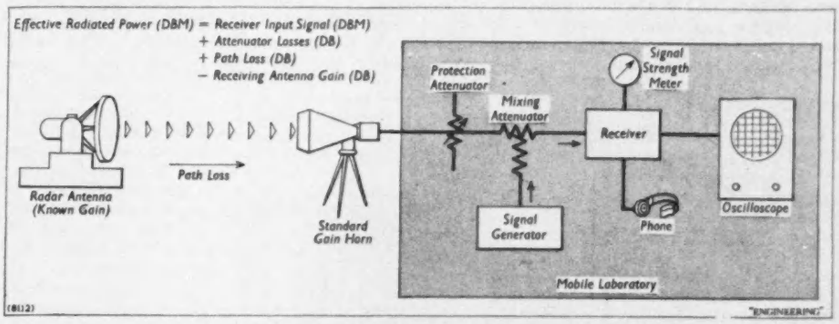
When aiming is completed, the engineer matches pulses from a signal generator with those from the radar in frequency, pulse length and pulse rate; he also measures the peak pulse power received. Having done this he determines the actual lose in propagation path and compares the measured loss with a calculated one. If the two are in good agreement, the engineer proceeds with the tests. If not, he moves to a better test site.

Having checked the propagation path loss, the engineer scans the entire frequency band for harmonics and spurious signals. If he finds a spurious signal he matches the signal generator to it. From this he can compute the effective radiated peak power of the radar at that frequency. Measuring equipment now available covers the frequency spectrum between 950 and 26,000 megacycles per second.

MANY RADARS INVOLVED

With the cooperation of the US armed services, Bell engineers have investigated 11 different types of radars in America. Their peak power outputs ranged from 140 kW to 5 MW. All were found to radiate harmonics or spurious signals of appreciable strength, and all of them radiated signals in one or more of the common-carrier frequency bands. These then are all potential sources of interference with communications signals.

Strangely enough, there have been relatively few reports of radar interference on these bands, and four possible reasons have been suggested for this. First, many of the microwave receivers are fortuitously screened from radar transmitters by natural obstructions such as hills, or by man-made obstructions such as tall buildings. Second, potentially interfering radars may be operating on frequencies at which their spurious outputs do not conflict with the frequency bands of microwave receivers operating in that vicinity.



An interference measuring equipment has been developed which can be used to determine propagation losses and then scan a large frequency spectrum for harmonics and spurious signals from radar.

A third possibility is that interference only occurs during fading periods so that its proper identification is difficult. The fourth and final hypothesis is that operating personnel do not recognise and report radar interference because of confusion with other types of interference from both natural and man-made sources.

MANUFACTURERS' EFFORT

Radar users and manufacturers in the USA are becoming increasingly aware of the potential seriousness of interference with microwave radio facilities. As a result, manufacturers are now taking steps to minimise extra band radiation by developing improved devices and equipment. For example, they are using improved magnetrons and klystrons with tighter specifications, better methods of filtering, and equipment with more favourable pulse shapes. In addition, radar users are striving to improve their operation and maintenance procedures. Microwave communication engineers are also now employing a number of schemes to reduce interference. Such factors as aerial directivity and cross polarisation of the communication waves with respect to radar radiation are among the devices being used. By such means, interference problems that might otherwise reach intolerable proportions may be brought under control.

As yet, the problem of radar interference does not seem to have occurred, or has not yet been recognised, in Great Britain. However, it is almost inevitable that difficulties will arise in due course if steps are not taken to overcome the incompatibility of the two systems.

Rough Linings for Fluid-Flow Experiments

By T. Constantine, Ph.D., B.Sc., A.M.I.C.E.
University of Manchester

In order that more can be known of the flow characteristics of fluids, experiments must be carried out on models which simulate the boundary conditions between fluid and container. A technique is described for accurately producing the rough surfaces.

OVER the last 50 years considerable research has been carried out on the effects of surface roughness on the flow characteristics of a fluid moving past a boundary surface. However the present state of knowledge is far from complete, and it would appear that before any significant advance can be made it will be necessary to define the primary roughness characteristics and the extent to which each affects the velocity distribution and surface resistance. This research work will be of fundamental importance.

Probably the most accurate way of carrying out the work experimentally is to use water flowing under pressure through a cylindrical pipe which has been artificially roughened. It is, of course, necessary to carry out a considerable number of tests varying each roughness parameter in turn, and if a good accuracy is to be maintained a considerable length of large diameter pipe has to be used. This in turn involves many thousands of roughness elements per test. For example, the working length of a 6 in diameter pipe needs to be at least 60 ft long and if $\frac{1}{8}$ in diameter cylindrical elements at $\frac{1}{4}$ in centres are used it means that 200,000 elements per test are required. The obvious method of drilling holes in the pipe and fitting the roughness elements individually is out of the question and if experimental work is to be carried out it is necessary to develop a better technique for making long pipes lined with roughness elements the shape, size and pattern of which can be changed relatively easily and cheaply.

MASTER ROUGHNESS PATTERN

Faced with this problem some time ago the author spent a considerable time developing a satisfactory technique. Briefly it consists of making first a master pattern of a 6 in length of rough pipe and then a rubber mould of it. From the rubber mould plaster shells are cast which are used to line the experimental pipe line. It is in the hope that the technique will be helpful to other research workers in this field that the method is described here in detail.

It should be noted that the following description of the manufacture of the master pattern refers to the method which the author would adopt in future for experiments using a rough pipe 5·73 in internal diameter with $\frac{1}{8}$ in diameter roughness elements at $\frac{1}{4}$ in centres. In actual fact the master pattern used and which is shown in the photograph was a modification of a 3 ft pattern split longitudinally which was used earlier in the development work.

A flanged master pattern 9 in long and 5·73 in internal diameter is made from a non-standard steel pipe. A series of radial holes at $\frac{1}{4}$ in centres over a 6 in length of the pipe are drilled prior to the final boring. The radial holes are reemed out to take $\frac{1}{8}$ in diameter silver steel rods 1 in long and these are forced through individually until they are just proud of the internal surface. The pipe is then bored out to the final diameter leaving a smooth internal surface. It is advisable to heat treat the pipe after each major machine operation to lessen the risk of deformation. By pushing some pegs through and leaving others flush with the internal surface any pattern or height of roughness can be obtained. The master pattern used in the development work is shown in Fig. 1. It will be noted that the internal surface is far from perfect but it was considered satisfactory for the development work. A steel base plate and a cylindrical steel tube 9 in long and approximately 5·2 in external diameter with a smooth outer surface and a slight taper from bottom to top are then made. These are as shown in Fig. 2. The master pattern plate and tube are inspected to ensure that they are perfectly clean. Releasil Fluid (by Midland Silicones Limited) is applied very sparingly to the parts, every care being taken to ensure that the whole internal surface of the pattern is covered.

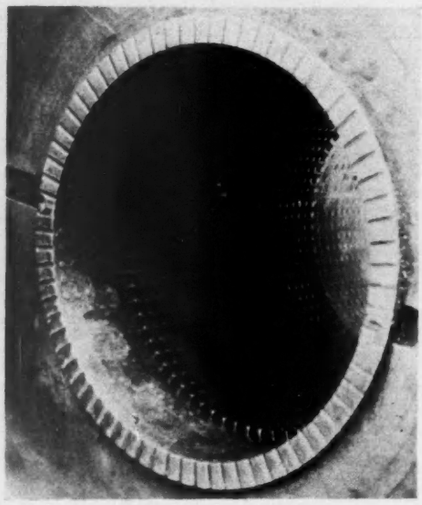


Fig. 1 Experimental master pattern, in which steel pegs are used to simulate a rough surface

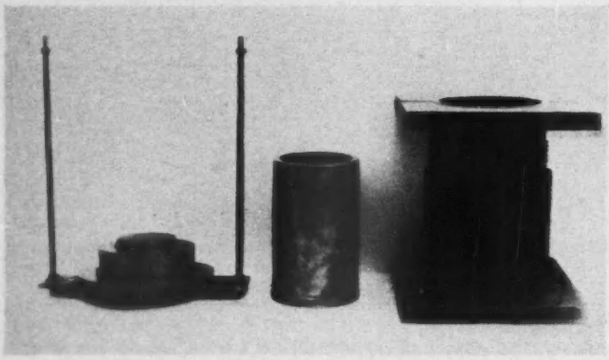


Fig. 2 Baseplate (left), tapered inner tube (centre) and master pattern assembly (right). The pegs on the master pattern can be moved in and out to give the required "roughness" inside the cylinder.

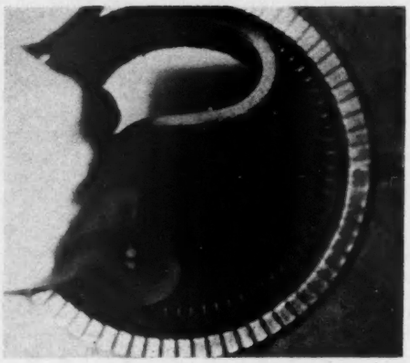


Fig. 3 Care must be exercised when removing the rubber mould from the master pattern.

A good method of applying the fluid is by spraying in a fine mist, a dilute solution of the fluid in a volatile solvent such as carbon tetrachloride. The purpose of the Releasil fluid is to prevent the rubber compound sticking to the roughness elements while curing is taking place. The tube is placed concentric with the master pattern and both are mounted on the base plate and placed in a thermostatically controlled oven and left at a temperature of 100° C for 4 hours. This ensures that the metal is heated uniformly throughout. Liquid rubber compound (Lorival Grade CRP) is then poured very slowly into the gap between the inner steel tube and the roughness elements, care being taken that none falls directly on the protuberances.

CRITICAL CURING

The rubber, which takes about 20 minutes to fill the space, rises slowly expelling all the air pockets. It is then left in the oven for 2 hours at a temperature of 100° C to vulcanise. The curing period should not be too long or too short, otherwise sticking will occur or the rubber will become "cheesy." The hot assembled pattern is removed from the oven and cooled rapidly with compressed air and solid carbon dioxide down to a temperature of 70° C. Thereafter the cooling can be allowed to occur naturally at room temperature since the amount of vulcanising which takes place at a temperature below 70° C is negligible. When cold the base plate is removed and the tapered steel tube withdrawn. Care must be exercised when the rubber mould is removed, an operation that is shown in Fig. 3.

It is quite probable that the method just described could be improved by using a room temperature curing compound. This would eliminate thermal expansion and subsequent shrinkage of the rubber. The main disadvantage would be that curing takes about 5 days. However, this could possibly be fitted into a research programme so that there were no undue delays.

The rubber mould can now be used to make as many plaster casts as required. In order to do this it is necessary to make another baseplate and a cylindrical cast iron mould 6 in high and 6 in internal diameter with a smooth internal surface, which is capable of being split. The rubber mould having been soaked in a weak solution of wetting agent is shaken to remove excess moisture, replaced on the inner cylinder and mounted on a baseplate (see Fig. 4) inside the cast iron mould. The outer mould and baseplate must be lightly covered with mould

oil to prevent the plaster sticking. A dental plaster, having excellent reproducing properties, is prepared in the form of a thick cream and poured slowly into the gap, the mould being vibrated continuously. The vibration must stop before the initial set of the plaster. After the plaster has set, the outer mould is split as shown in Fig. 5 and the rubber mould removed, great care being taken that none of the roughness elements are broken off. The resulting plaster cast is very strong, and apart from a slight overall reduction in size it reproduces the master pattern very accurately.

The casting process is repeated until sufficient castings are available to line the necessary length of 6 in diameter pipe. The castings can either be butt-jointed, or it can be arranged to cast a spigot or socket in the plaster. While a test is being carried out on one roughness pattern the master pattern can be altered and a new set of castings made in readiness for the next test.

Roughness elements of a different shape would necessitate the elements being made in the form of pegs to fit in the master pattern but otherwise the procedure would be the same as before.

While even this method may sound laborious it is, in the opinion of the author, the simplest method that is likely to be found.

Acknowledgements

The author wishes to acknowledge the most valuable assistance he received from Dr. Stokes of Rubber Technical Developments Limited, and also to thank Professor J. A. L. Matheson for placing the facilities of the Whitworth Laboratories, Manchester University, at his disposal.

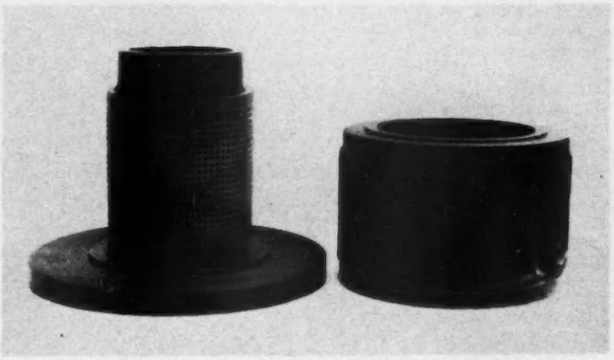


Fig. 4 When mounted on the baseplate, the rubber mould can be used to produce an almost unlimited supply of plaster roughness elements.

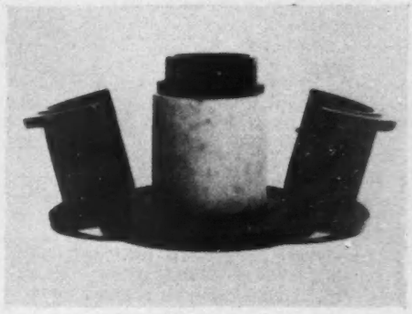


Fig. 5 When the plaster has set, the rubber mould is removed (as shown in Fig. 3), great care being taken not to break the plaster roughness pattern.

Flashlight Beacon for Tracking a Missile

An airborne optical beacon with a precisely timed flash that can be photographed from a distance of up to 400 miles has been developed by the Battelle Memorial Institute in the USA. It has been designed to be carried in missiles so that, when used in conjunction with ground based photographic equipment, it will permit a more precise study of missiles launched at night. The controlled high intensity flashes will be photographed as a series of dots to provide a record of the missile's trajectory. A radio signal will be used to control the beacon.

Apart from its capabilities, the beacon is of interest as an example of compact, precisely-engineered instruments built to rigid specifications. The first production model weighs 33 lb and is 27 in long and about 8 in square. When placed in the missile the beacon's lens will become an integral part of the missile's external surface.

Inside the beacon unit, there is a maze of transistorised circuitry which makes it possible to step up a nominal battery supply of 28 volts to something like 4,000 volts. The battery, consisting of a series of silver cells, is 7 in long and about 3 in square. The voltage upgrading is necessary to set off the flash tube light twice per second. The flash tube, similar to those used in photography, is a specially designed quartz tube filled with xenon gas, with an electrode sealed in at each end. At its peak, the flash emits light rated at 50 million lumens—the equivalent of 10,000 50-watt bulbs flashed simultaneously.

Since the value of the beacon lies in its precise timing, the unit has been designed so that each flash does not exceed 10^{-4} sec, as measured by standard illumination techniques. The timing between flashes is equally critical, the required accuracy being to the nearest 10^{-4} sec.

The precision required of the beacon, coupled with the unusual conditions under which it must perform, made it necessary for extensive reliability studies to be carried out. The beacon must continue flashing for a minimum of 25 secs. The optical beacon is also capable of withstanding environmental conditions from about − 80 to + 160° F at a relative humidity of 100 per cent. Under operating conditions, surrounding air temperature may vary from 40 to 130° F and the unit must withstand thermal radiation from the missiles walls, which may be at 700° F for about three minutes. The unit has also been designed to witsthand extremes of shock and vibration.

Improving Refractories in Open-Hearth Furnaces

Within recent years one of the most successful methods of increasing the production of steel has been the use of tonnage oxygen in open-hearth furnaces. This has, however, usually increased the severity of attack on the refractories. Consequently, a number of furnaces are now being fitted with more resistant, basic, roofs.

To improve the properties of roof bricks, research is being conducted by the British Iron and Steel Research Association. This work, done on a laboratory scale, has shown that the volume stability and the refractoriness-under-load can be increased by careful selection of materials and by harder firing.

The design of supports for roofs is also receiving considerable attention and various trials are in progress in several works. In the Templeborough melting shop of the United Steels Company Limited the merits of fixed and heavily spring-loaded back skewbacks are being compared on full furnace roofs of restrained curvature. Plans are also in hand for studying a number of designs on the company's full-span test rig.

In the Abbey works of the Steel Company of Wales, the first BISRA flexible panel of basic bricks, built over the end of a furnace, lasted 617 heats (about one year). This was roughly four times the average life of several normal fixed skewback panels built in similar positions for comparison. The contrast between the slow dripping of the flexible panel and the wasteful spalling of the fixed skewback panel was marked. The BISRA panel would probably have lasted even longer but for the interference of an adjoining silica ramp, which caused some spalling to spread along the crown from the point of contact. Although the performance of this flexible panel was very promising, the roof movement was less than that predicted by theory. it is now thought that this was due mainly to hysteresis and damage by heat in the particular type of springs employed. A design using water cooled " liquid " springs is now being prepared for a full roof. Various additional problems have to be solved, however, such as the shape of the back skewback channel and the need for a clear space over the taphole. To facilitate the analysis of data from instruments during future roof trials, an adaptor has been fitted to a normal chart recorder; this will enable the signals to be transferred to a punched tape record suitable for direct handling by the BISRA computer.

A second flexible panel, incorporating minor refinements, has been in operation for some 300 heats. The main difference in this trial was the omission of steel plate joints, to avoid the repetition of the growth of oxidation which was observed in those fitted in the first panel. This plateless construction, however, has not been as satisfactory as was expected. The behaviour of steel plates under pressure between blocks of chrome-magnesite maintained at high temperatures is therefore being studied in the laboratories.

Routine data on silica roofs have been analysed by the operational research department of BISRA There is now strong evidence that the effects of differences in the refractories are swamped by other variables such as roof design and differences of operation. Some of the tentative indications, however (for example, on the benefits of low porosity and alumina) agree with the results obtained with more direct experiments. It has been recommended that the maximum safe rate of heating silica roofs is 60° C per hour up to 600° C.

Detergent Difficulty

It is unfortunate that what may be a blessing to one person can raise problems for another. The synthetic detergent that has eased washing difficulties, particularly in areas of hard water supplies, has created trouble for the sewage disposal authorities because it remains after normal treatment of the effluent and causes serious foaming in rivers and streams.

Synthetic detergents—syndets in America—are a war-time product. "Natural" soaps are made from animal or vegetable fats, which were in exclusive demand during the war for making margarine. As a result the chemists had to produce something else for washing and developed the syndets from mineral oils. Like soaps, they have a long chain molecule of carbon and hydrogen but usually with a sulphur group added at one end. Their basic ingredient, the one that really does the work, is alkyl aryl sulphonate. It is unaffected by hard water or by boiling. Nor does it absorb water and so become caked in the packet.

Unfortunately this substance does not hold the dirt in suspension and, if used alone, would allow it to settle back on the washing. Therefore a very small amount of sodium carboxymethyl-cellulose is added which keeps the dirt in suspension and so ensures better all round cleaning. To these two are added other ingredients which may include a foam stabiliser (syndet foams, unlike soap, are short lived); a bleach; "builders" which are alkalis that build up the activity of the main ingredient; and possibly "optical white," a colourless fluorescent dye that gives out a bluish white light and so improves the "whiteness" of clothes. Full surveys of commercial detergents, their analysis and effectiveness have been carried out by both *Which?* and *Shopper's Guide*.

The unfortunate side of the matter is that the syndets are not broken down by normal treatment in sewage disposal plants. The result is that the effluent from these plants foams at the least turbulence and any small waterfall or weir can become a first class foam generator. It is not uncommon for several feet of foam to form on the surface—both unpleasing and dangerous. With a wind, it is quite usual to see neighbouring hedges plastered with football-size lumps of foam and smaller lumps of it bowling merrily across the fields. The foam also means that the detergent is still present in the water, causing concern to those authorities who draw their water supplies from the same rivers, quite apart from the effect it may have on aquatic life.

A standing committee to watch over the position was appointed in 1957 and their third Progress report was published last April.* A table shows how the use of syndets has increased. In 1949 the annual consumption of the basic ingredient, the surface active agent, in the United Kingdom was 13,000 tons made up of 10,500 tons for domestic use and 2,500 tons for industrial concerns. In 1959 these figures rose to 37,500 and 7,400 tons respectively giving a total of 44,900 tons. The main part of the increase during the past two years seems to have been due to greater use of liquid syndets which are mainly sold for washing-up.

The committee record that British Waterways again expressed grave anxiety at the amount of foam on some navigable waterways and also their apprehension that anyone falling into any foaming river or canal would have little or no prospect of rescue or survival. Anxieties about the effect of syndets on septic tanks appear to be groundless.

Within disposal works the foam can cause blockage of the channels and a general slowing down of operations. One method of prevention is to use some anti-foam agent, which adds considerably to the cost of treatment. When first operating, the new sewage works at St. Helens suffered badly from foaming and overcame it in this way. On the other hand, works in the Hogsmill Valley experienced no foaming troubles and showed an unusually high removal of active material. It is believed that this is due to the very high degree of aeration employed at these works—a result that accords with results obtained by the Water Pollution Research Laboratory.

Research, however, has found that in general alkyl benzene sulphonates are more amenable to biological decomposition if the alkyl branch of the chain is a simple one and not branched. Manufacturers are cooperating with the committee in a full scale experiment to prove this, using the upper valley of the river Lee (in Hertfordshire) for the trial. Local authorities of both Luton and Harpenden readily agreed to cooperate in the trials, which were begun in August 1958.

The effluents from Luton (about 9 million gallons a day) and from Harpenden (about 0·6 million gallons per day) flow into the Lee, and later the river passes over Lemsford weir where there is nearly always some foam to be seen. About 25 miles further on water is extracted for the Metropolitan Water Board for supply to London.

It was arranged that as far as possible only syndets containing the "soft" material should be supplied to the two towns, and surveys have shown that these now constitute about 60 per cent of all used there. Prior to the commencement, the concentration of syndets at Luton in the settled sewage and in the effluent were 8 ppm and 3 ppm respectively, representing a removal of 63 per cent. At Harpenden the corresponding figures were 16 and 6·5 ppm, representing a removal of 59 per cent. In spite of various difficulties that arose during the tests, mainly concerned with sampling procedures, a very marked improvement has been obtained, as evidence by the reduction in foam at Lemsford weir. This is borne out by analysis made at Lemsford where the average concentration during 1958 was 1·4 ppm and in 1959 was 0·9 ppm. The fact that one-third of the detergent being used in the towns was still of the old "hard" variety reduced the total effect that might have been achieved.

* "Third Progress Report of the Standing Committee on Synthetic Detergents," HM Stationery Office (1*s* 6*d*).

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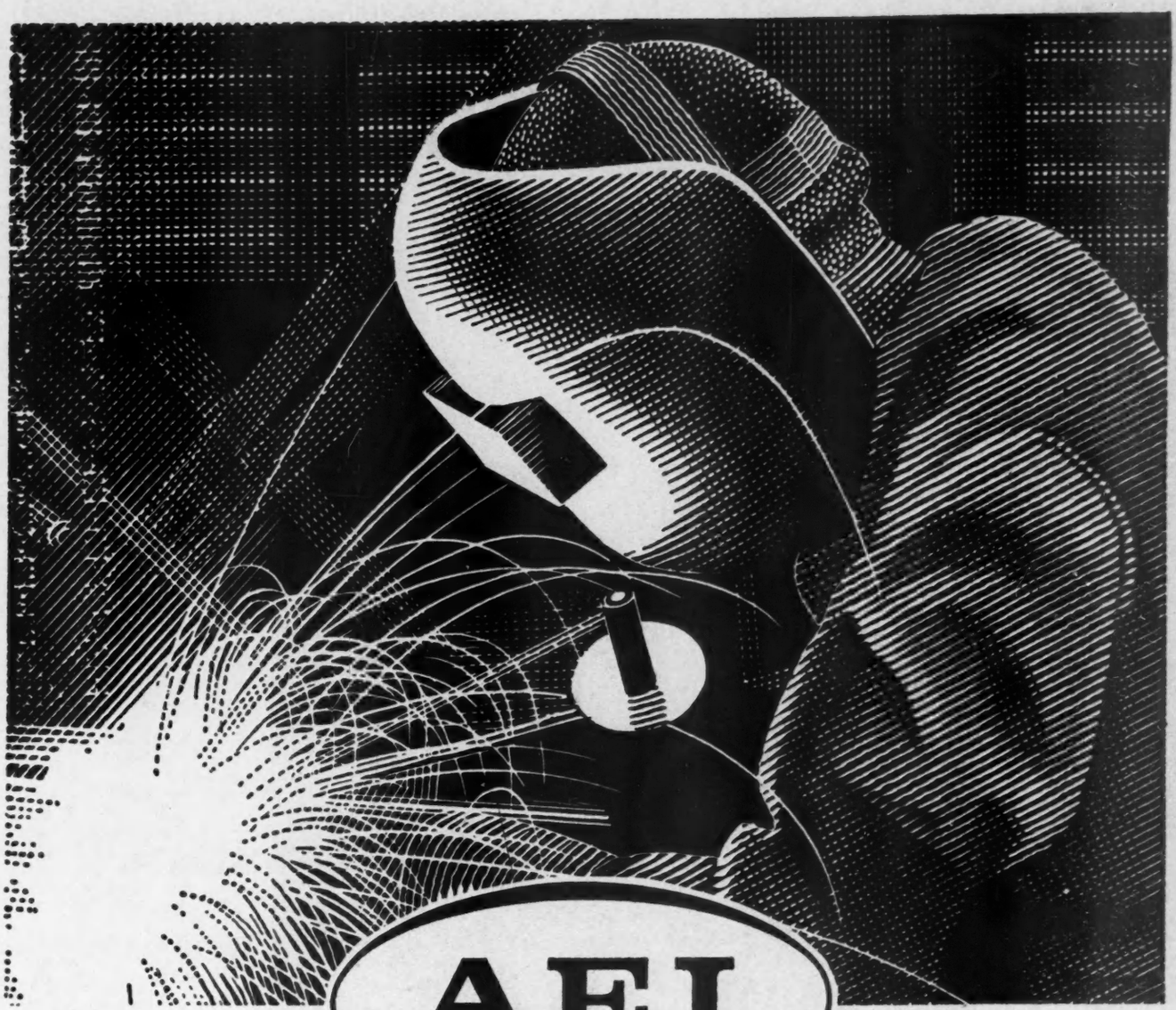

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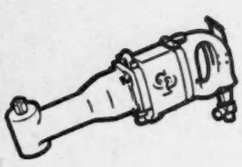

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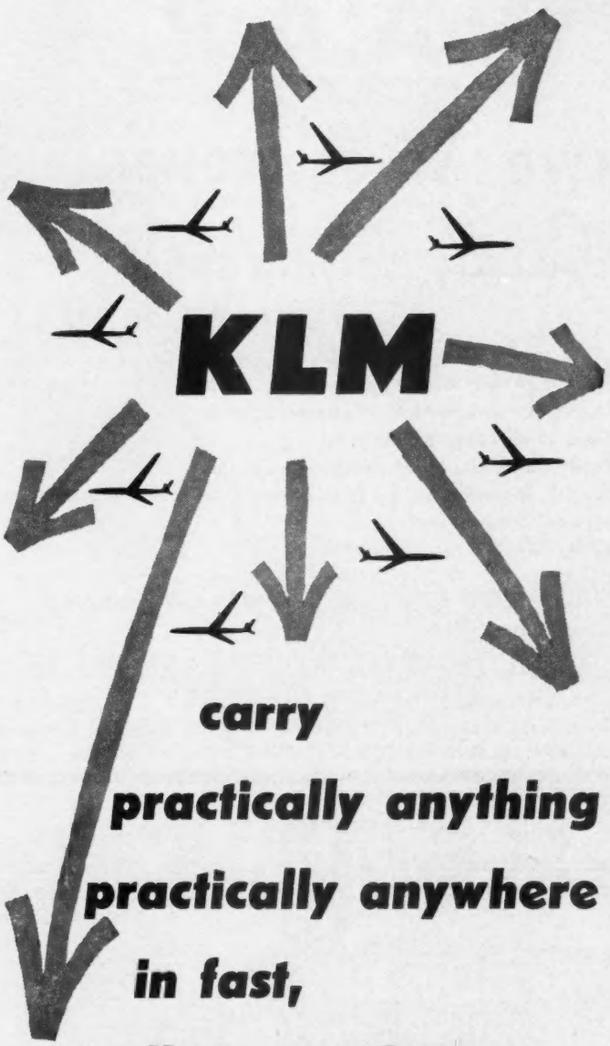

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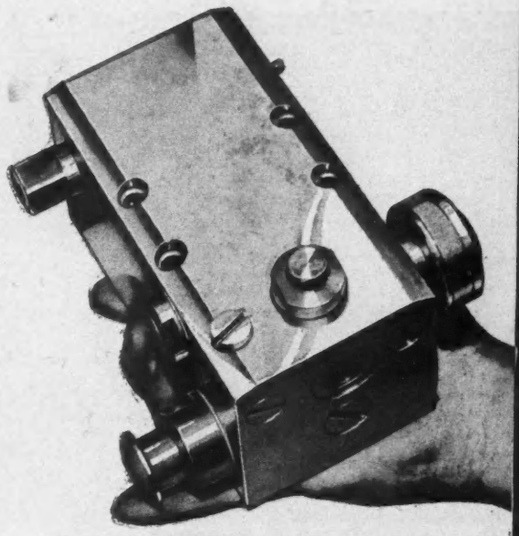

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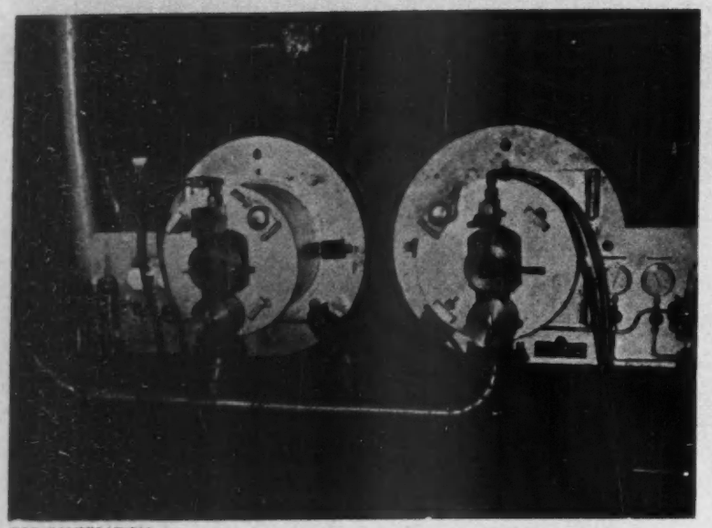

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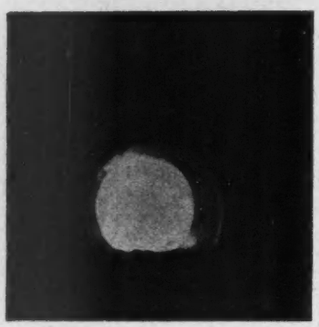

RIGHT
Photograph taken through the sight port of the combustion chamber of an Economic Boiler—approximate fuel output 350 lbs. per hour—CO_2 of over 13%—Smoke Number betwwen 1 and 2.

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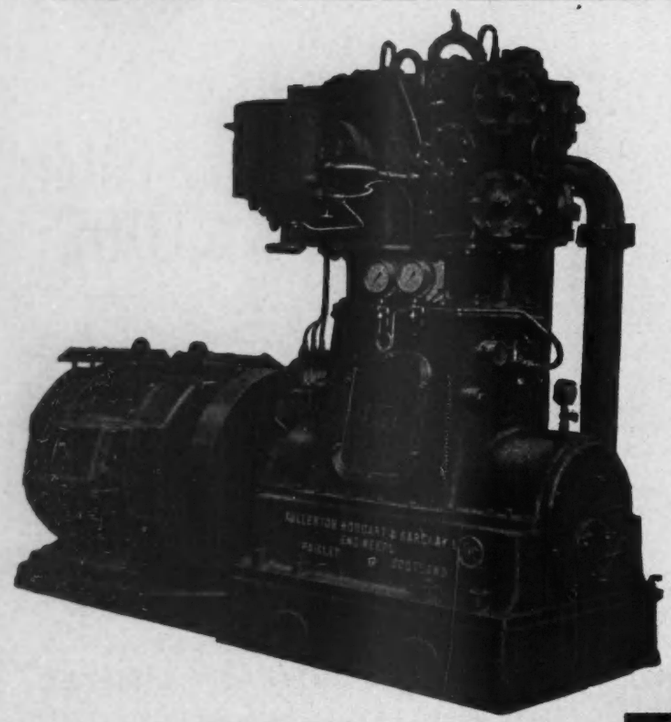

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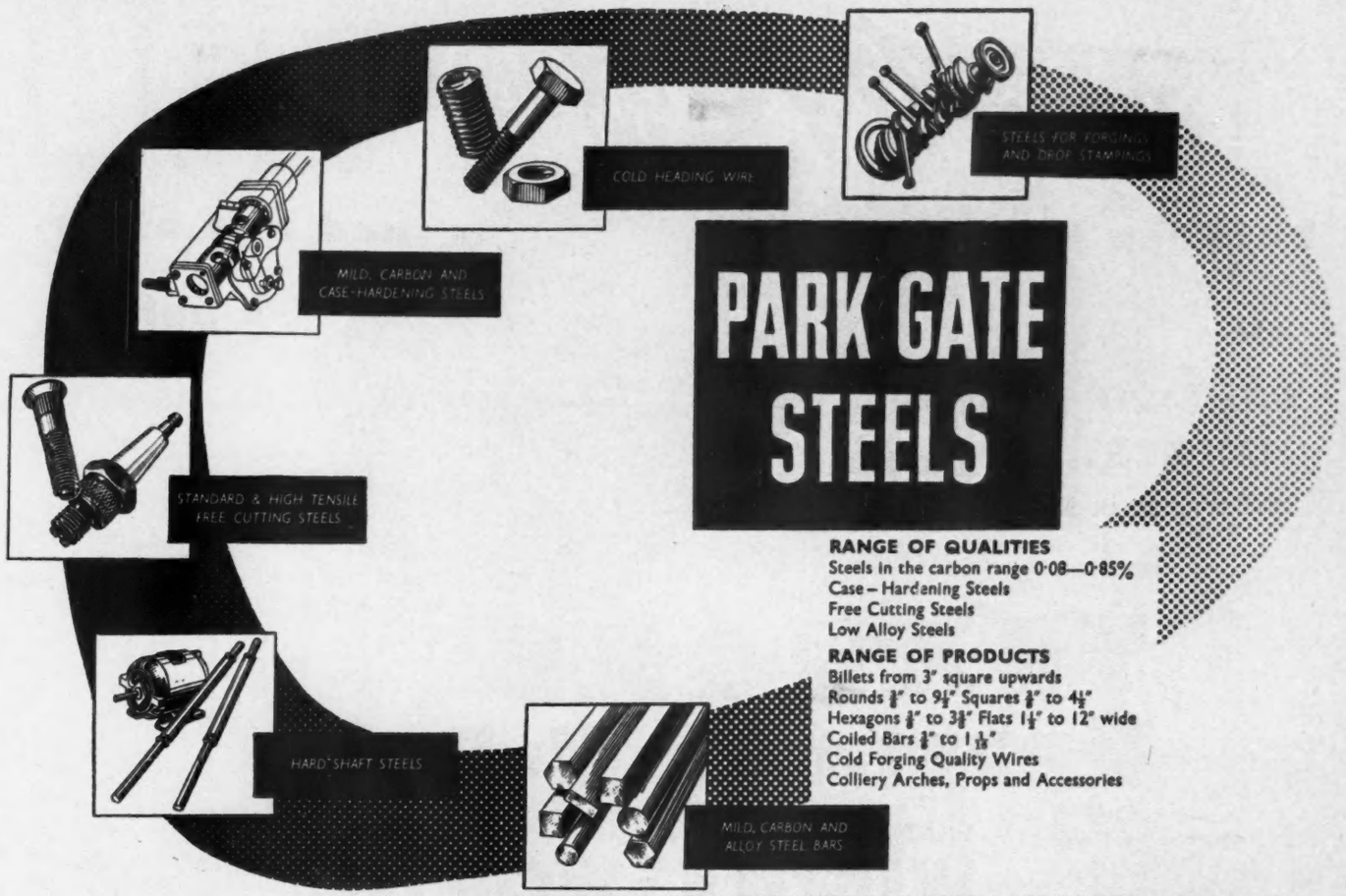
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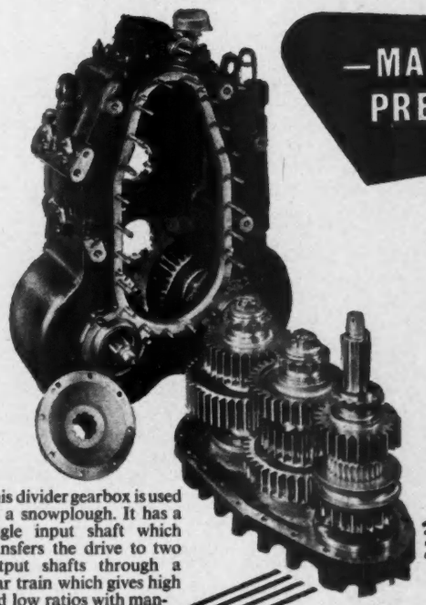
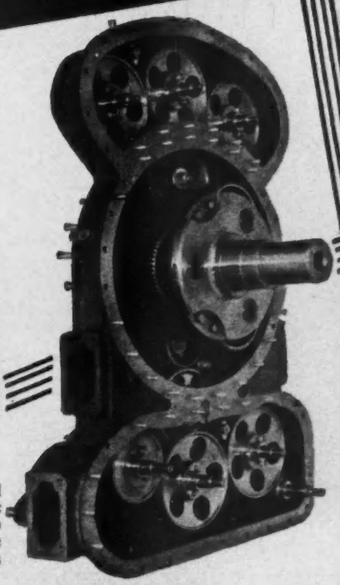


This divider gearbox is used on a snowplough. It has a single input shaft which transfers the drive to two output shafts through a gear train which gives high and low ratios with manual selection.



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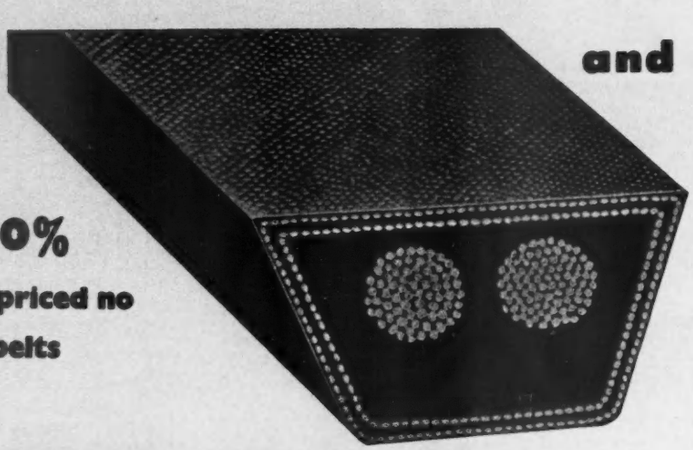

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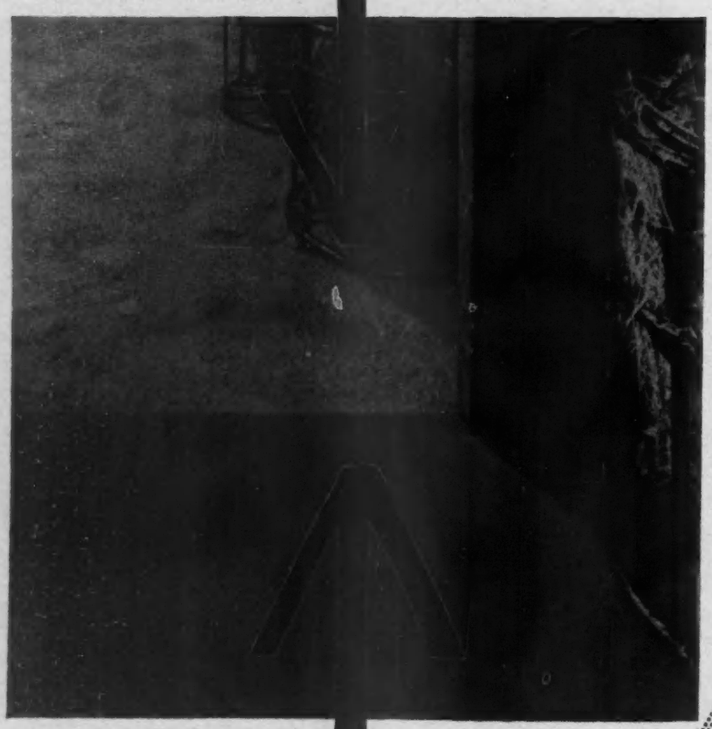

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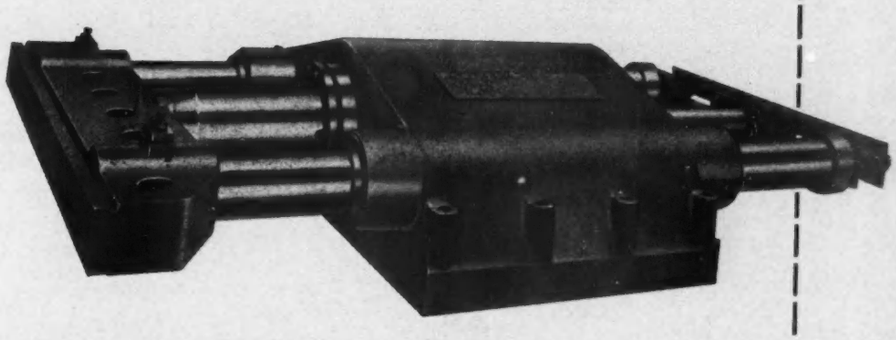

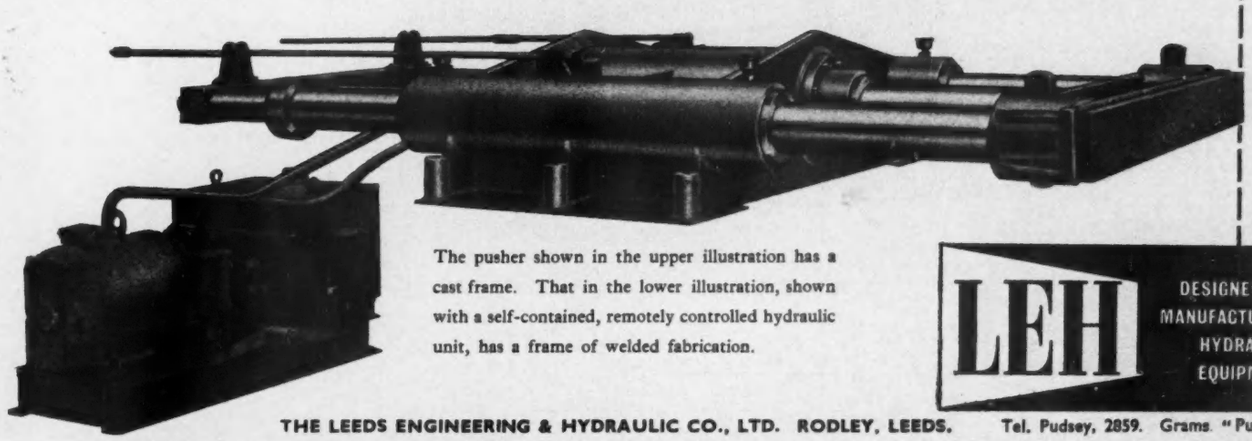

The pusher shown in the upper illustration has a cast frame. That in the lower illustration, shown with a self-contained, remotely controlled hydraulic unit, has a frame of welded fabrication.

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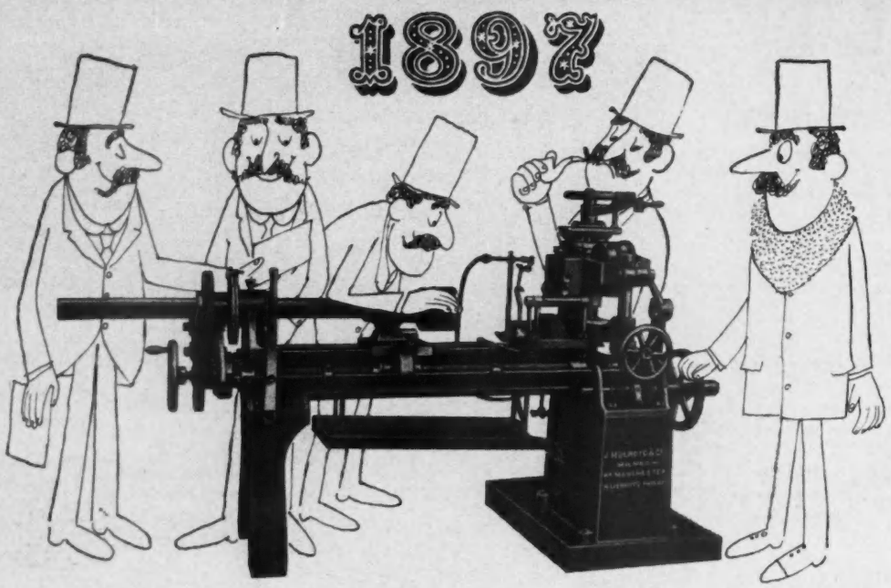

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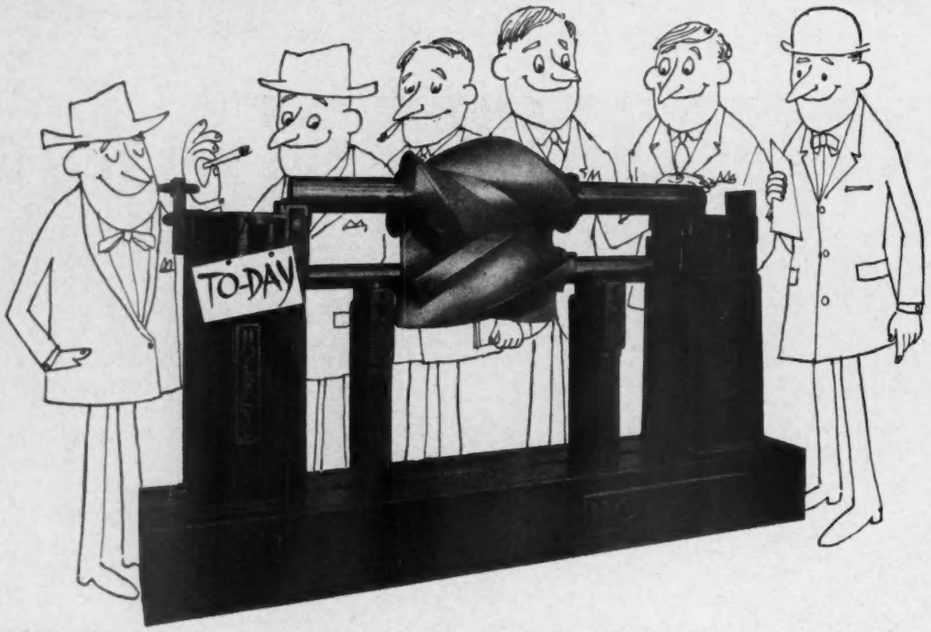

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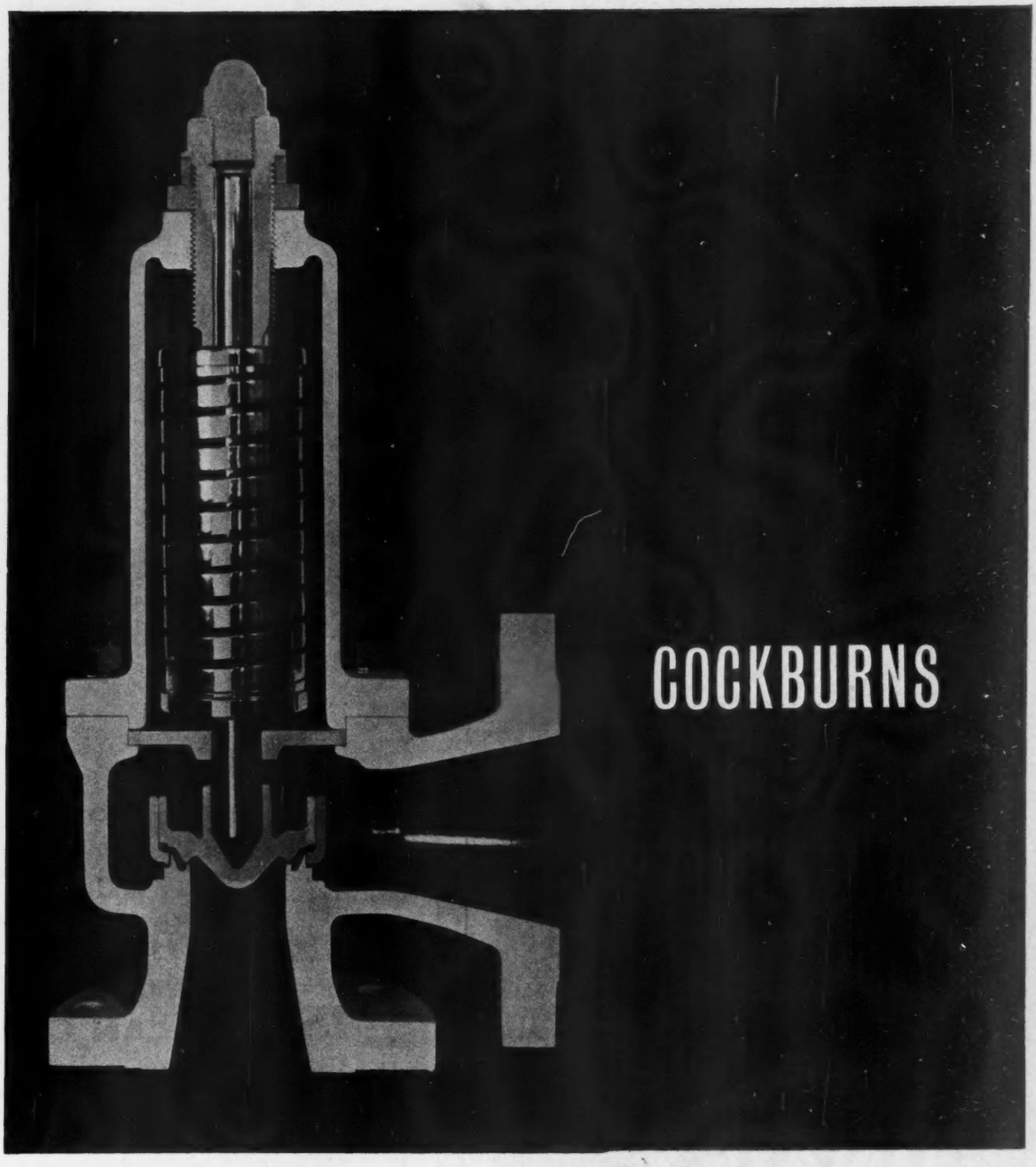

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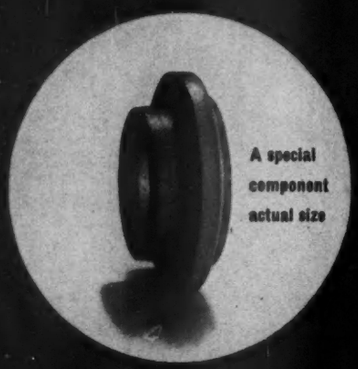

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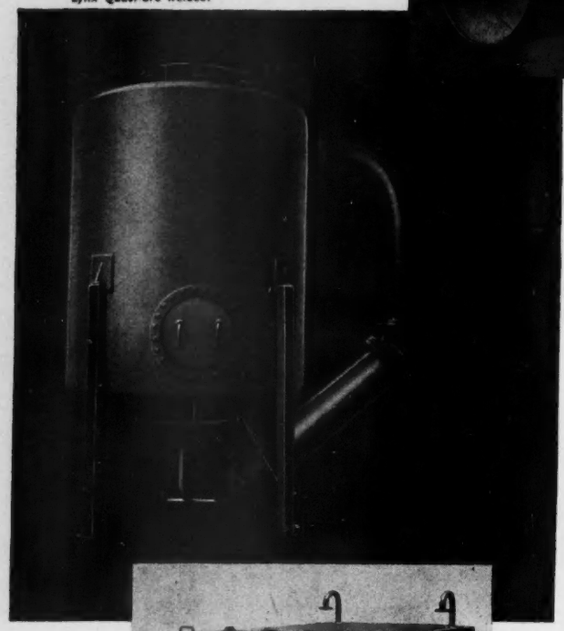

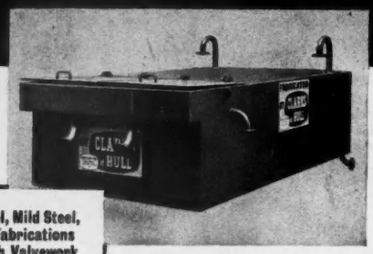

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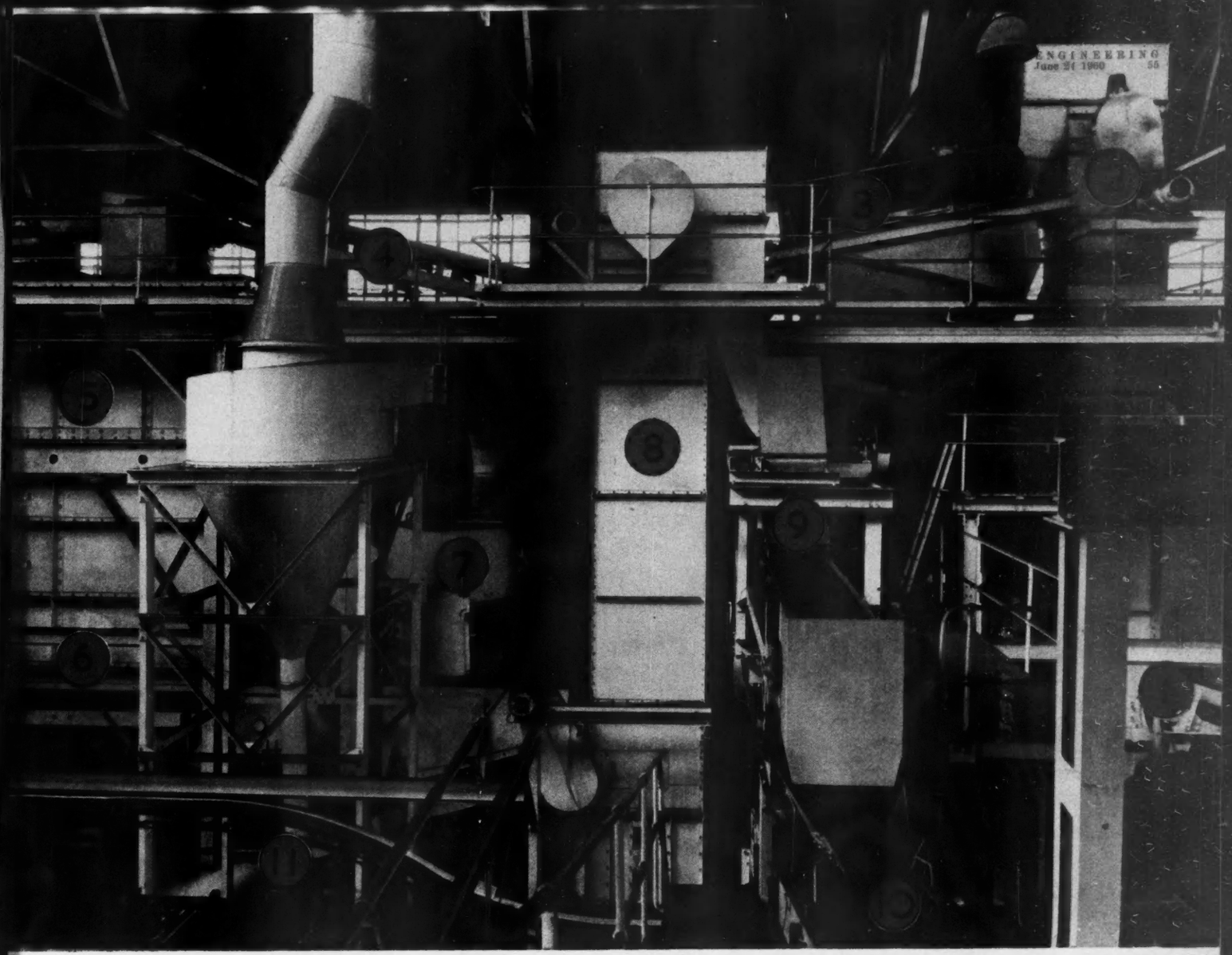

The illustration shows that part of a **MORRIS** foundry sand and mechanization plant which re-conditions knocked-out sand. At **1**, sand coming from the knock-out via an apron plate and belt conveyor passes beneath a magnetic separator (to remove tramp iron) and falls into the boot of a belt-bucket elevator, **2**, discharging into screen **3** onto belt conveyor **4** which in turn discharges into sixty-ton storage hopper **5**. The flat belt conveyor, **6**, under the hopper, pours sand into the skip which feeds the mulling machine (known as the Speedmullor). This machine **7**, providing a rapid mulling cycle with close batch control, discharges the sand into belt-bucket elevator **8**. From thence, the sand proceeds via belt conveyors **9** and **10** to the moulders. The overhead chain conveyor **11** serves the core shop with sand and also takes the cores to the stoves and to the moulders.

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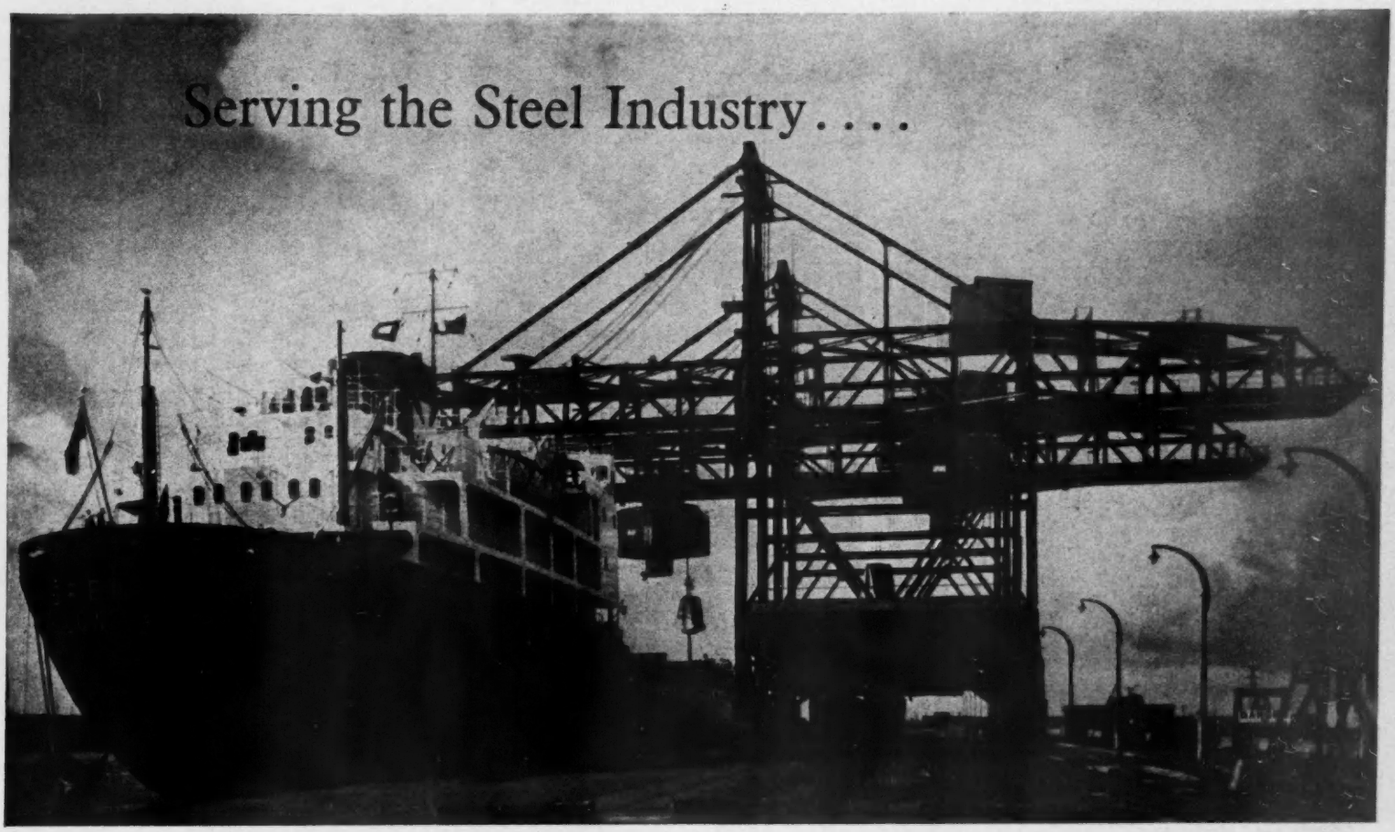
Hiduminium Aluminium



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is supported by eye-opening figures!

The vibration test

Two coupled assemblies of 3 types of tubing were placed in a vibration test machine and subjected to 1,100 vibrations per minute for 200 hours.

INSIDE DIAMETER:	¼″ *and under*
LENGTH OF SAMPLE:	8″ *minimum*
FREQUENCY OF VIBRATION:	1,100 *cycles per min.*
TOTAL AMPLITUDE:	1 1/16″
ARRANGEMENT:	1½″ *offset at 90° to direction of stroke*
INITIAL SLACK:	1/16″

Test oil at 250°F. and 45 p.s.i. pressure was circulated through the hose. Continuous visible leakage was considered as a failure.

Result Solvent Hose (Rubber) ..... *failed.*
P.V.C. and reinforced P.V.C. ..... *failed.*
Tecalemit Nylon Tubing ..... *satisfactory, showing no signs of deterioration after 700 hours.*

The swelling test *satisfactory after immersion in hot oil at 212°F. for 70 hours.*

The tensile strength test *successfully held a 100 lb. weight, after being dry-air aged at 212°F.*

The hot flexibility test *satisfactory after immersion in Derv at 212°F. for 200 hours.*

The cold flexibility test *having been aged in oil at 212°F. was found satisfactory after 5 hours at -40°C.*

The cold embrittlement test *satisfactory at -78°C. (other tubing broke before -38°C.)*

* Flexible or rigid Tecalemit Nylon Tubing successfully replaces plastic, rubber and metallic tubing on industrial oil and fuel lines. * Tougher, lighter. * Low cost.
* Fitting times almost halved. * No risk of loose internal abrasive scale.

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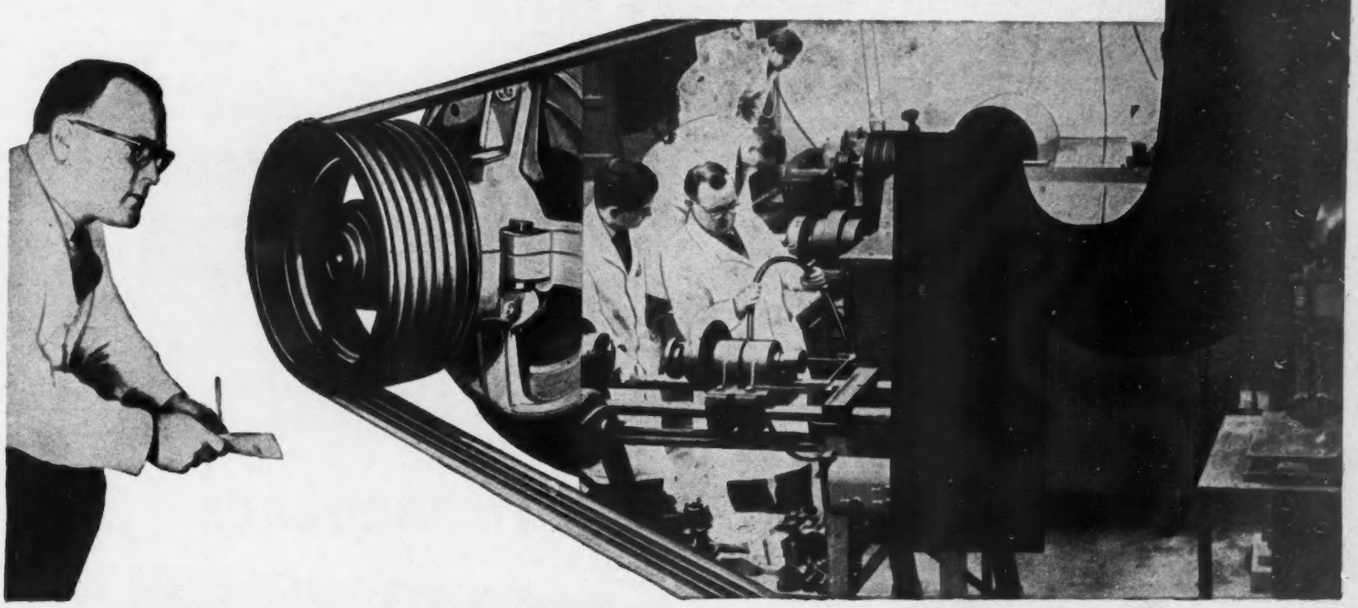

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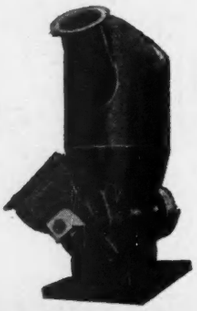

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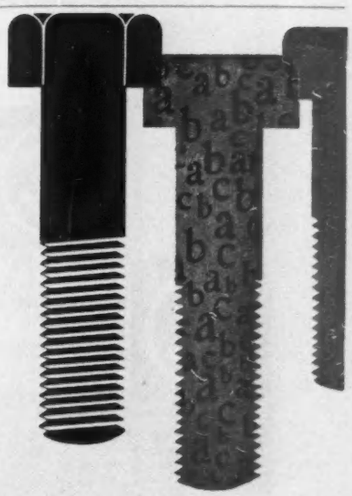

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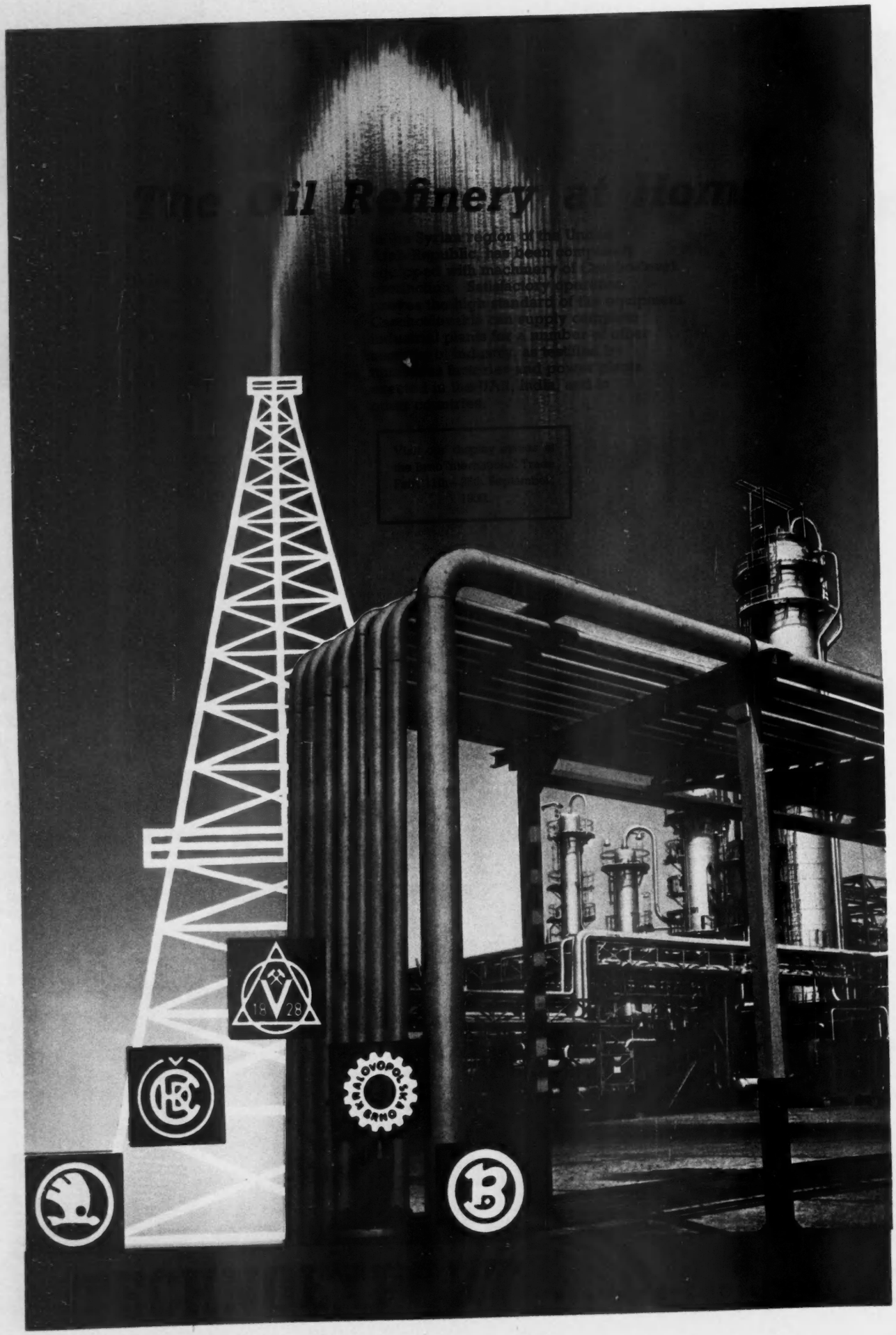
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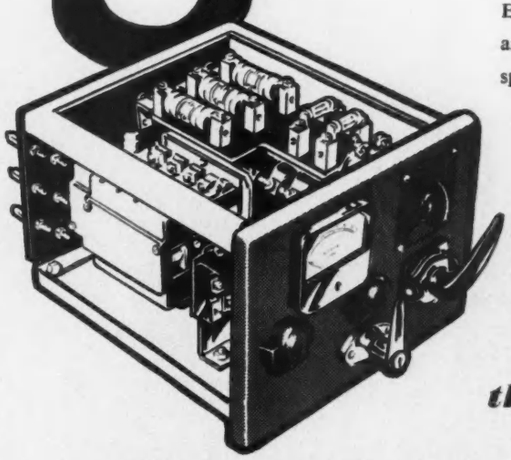

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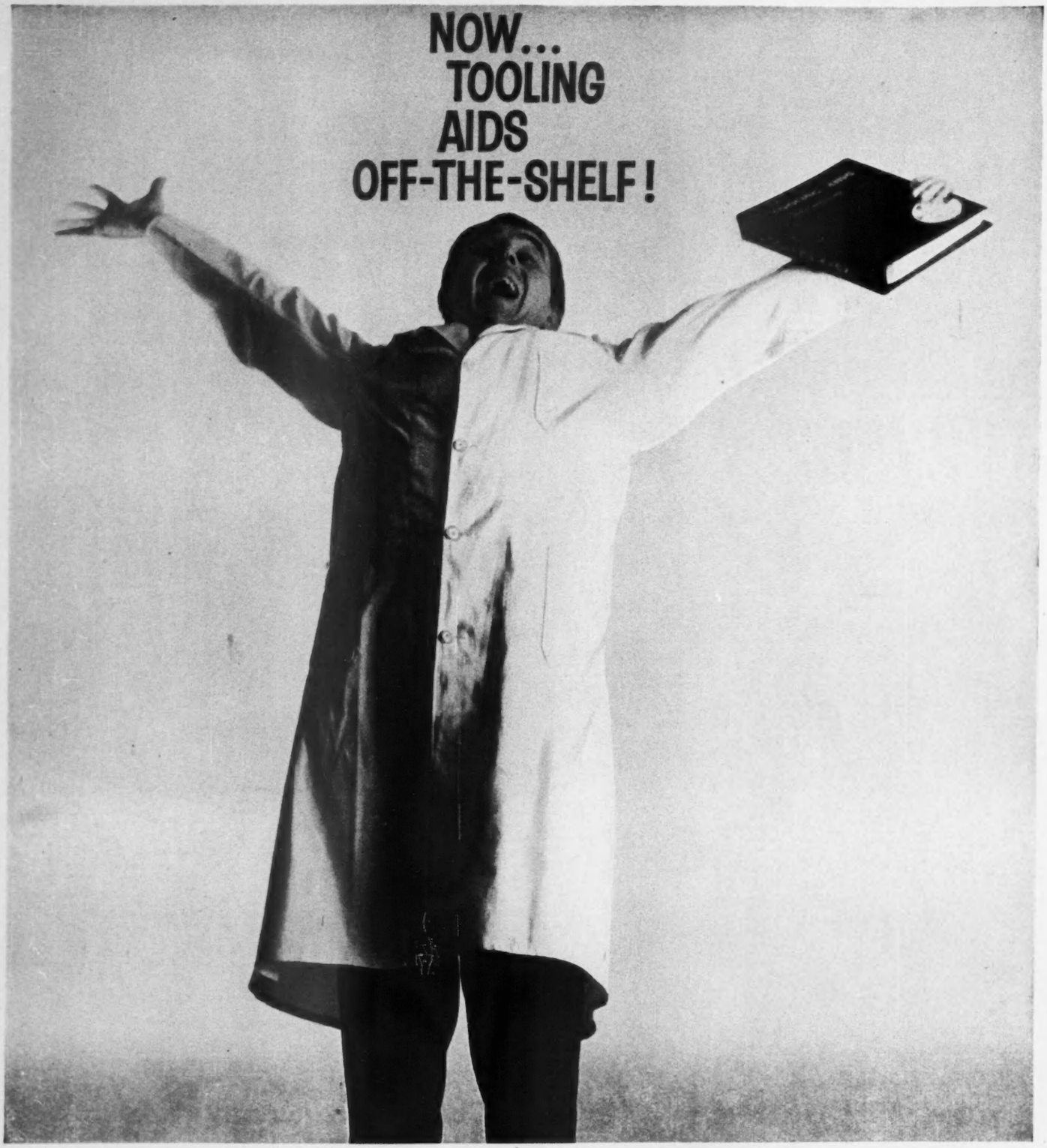

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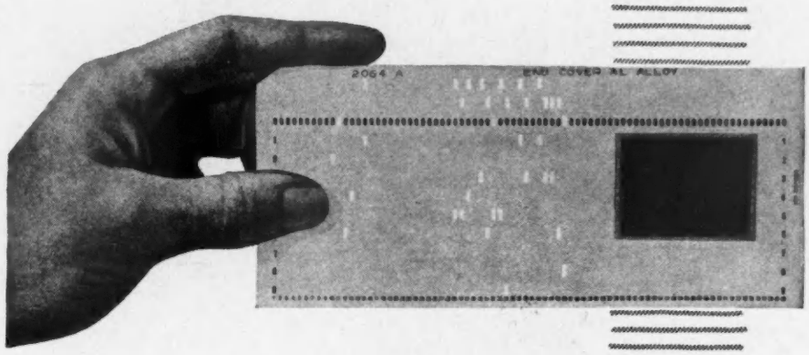

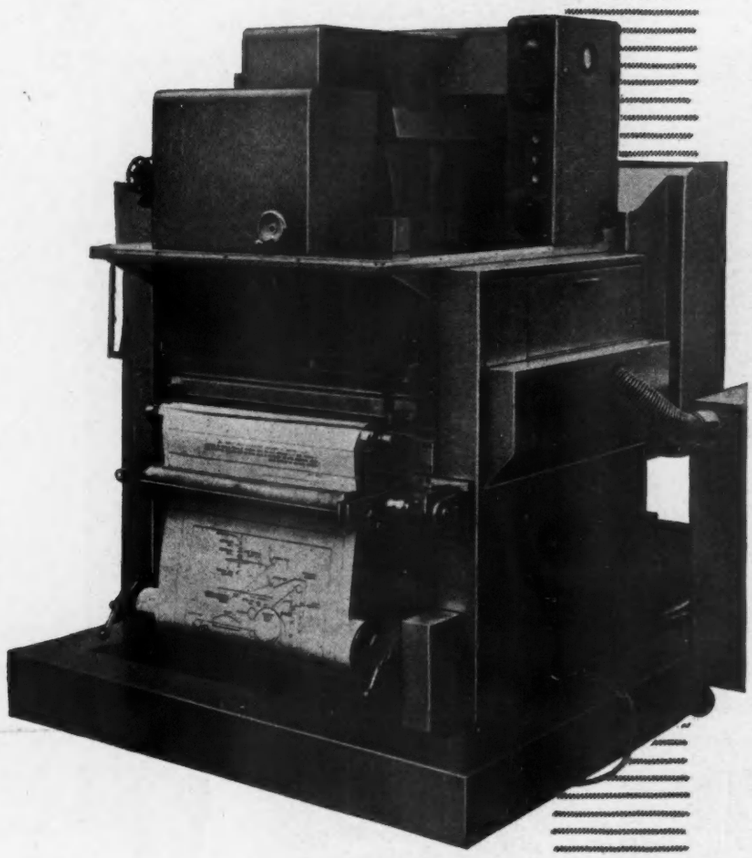

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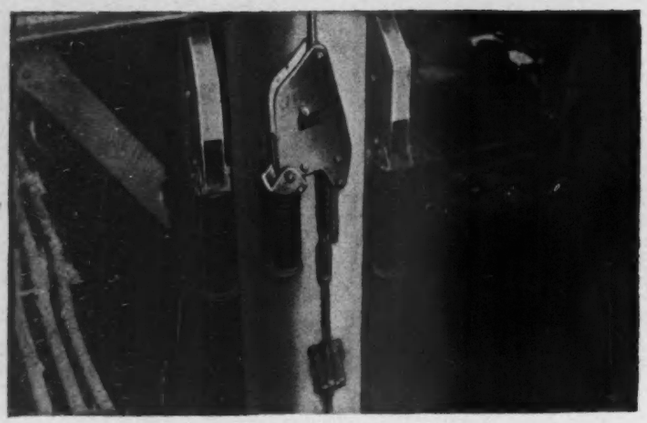

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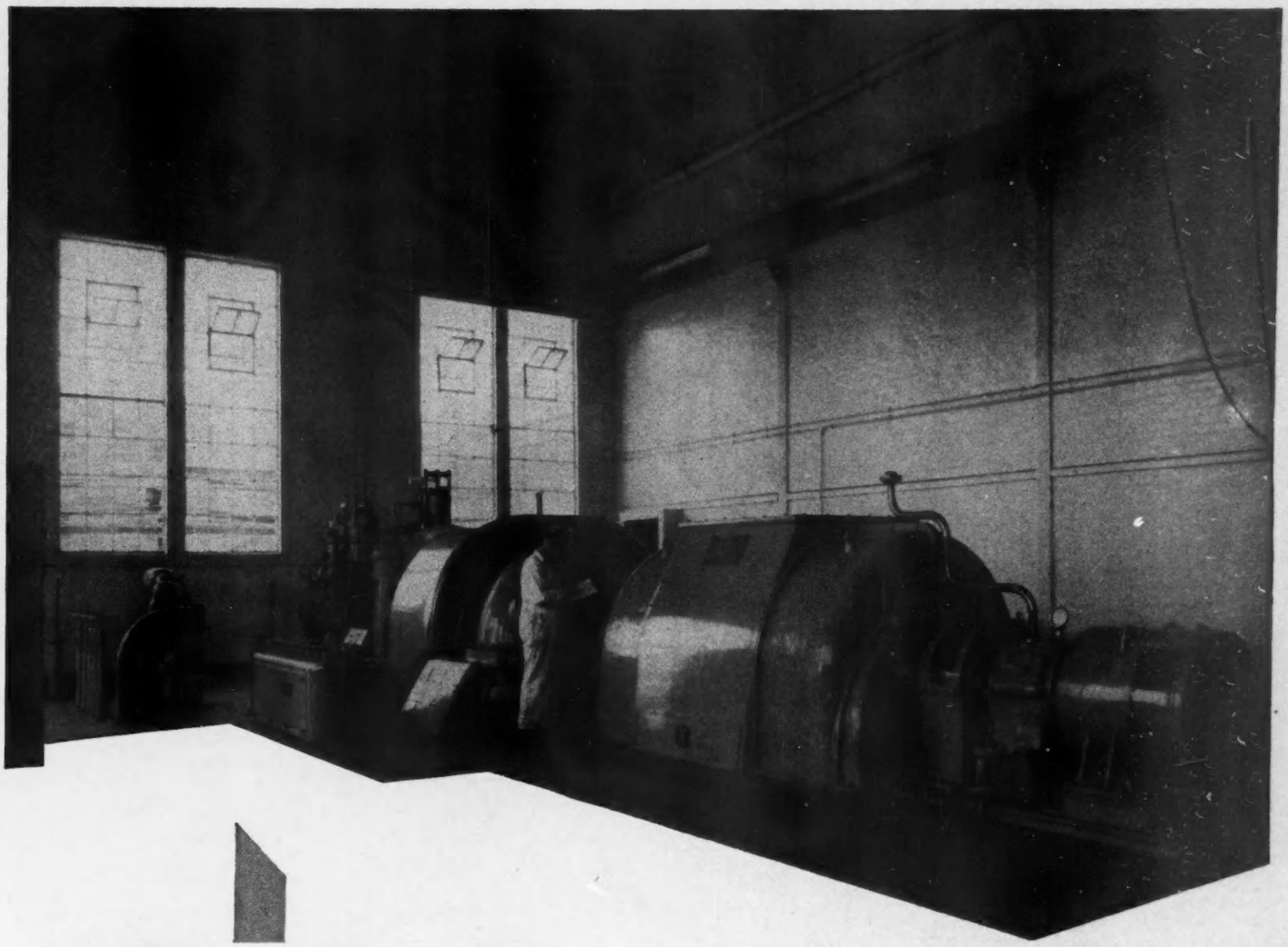

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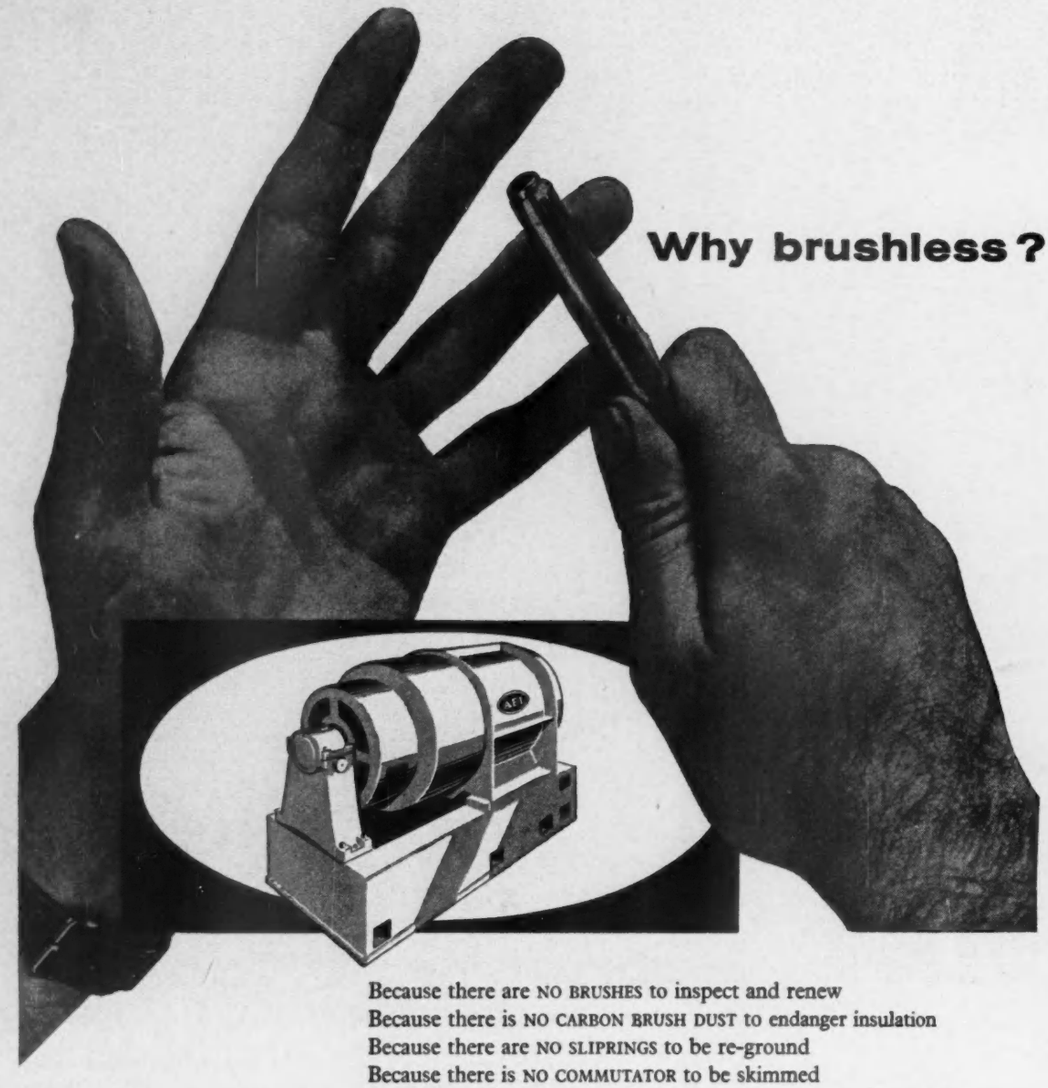

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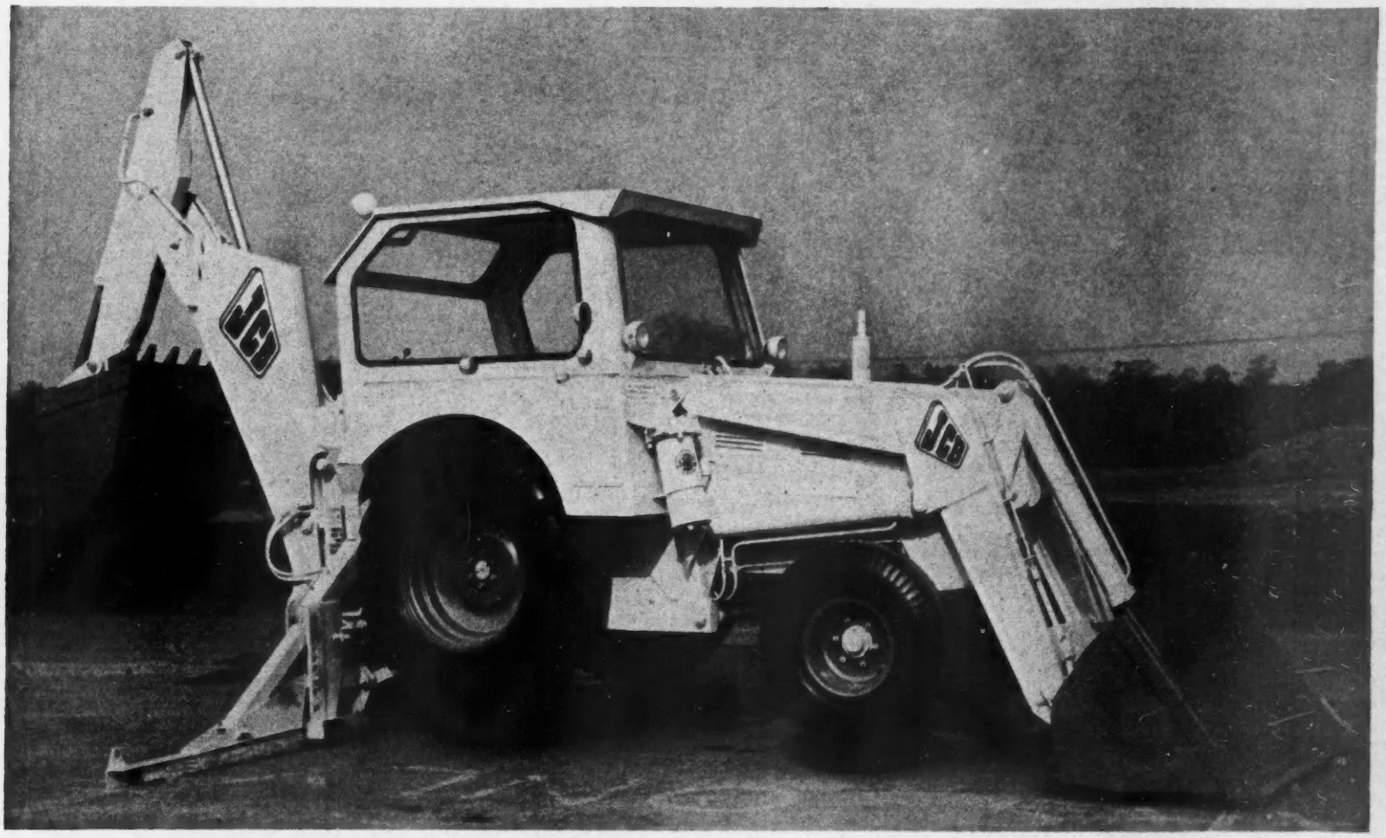

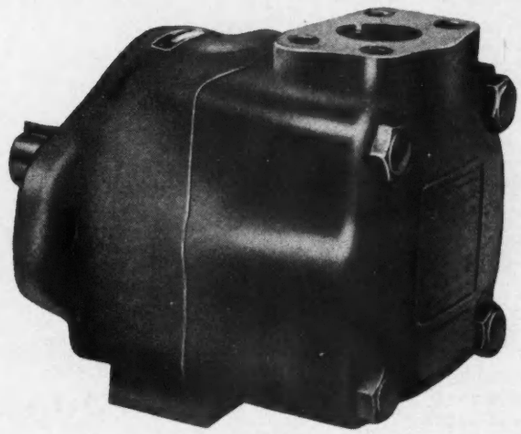

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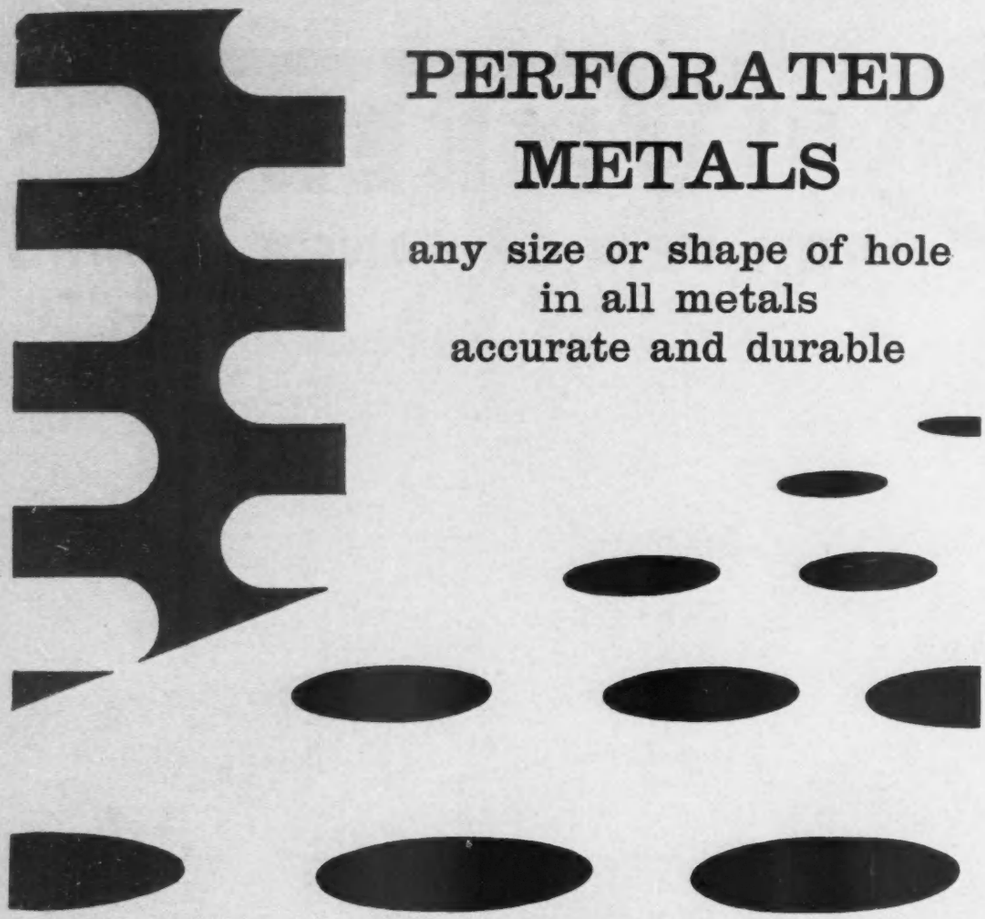

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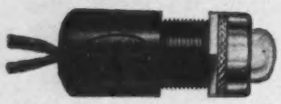

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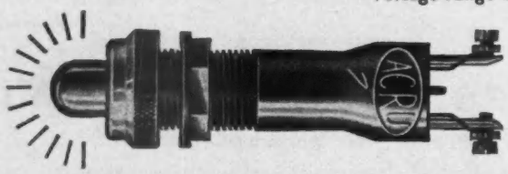

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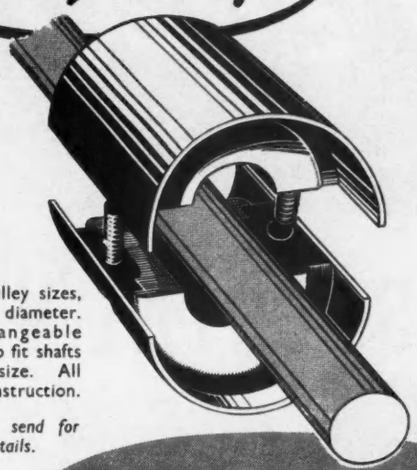

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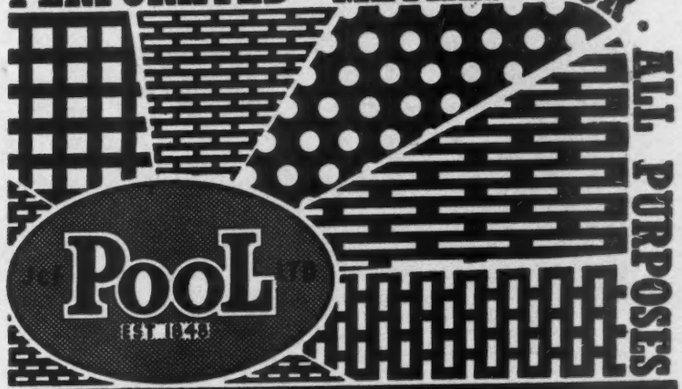

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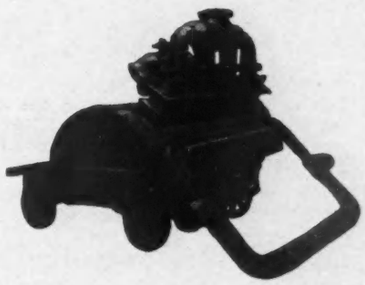

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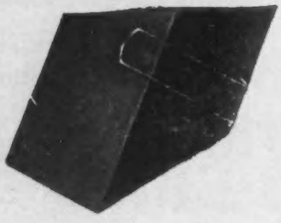

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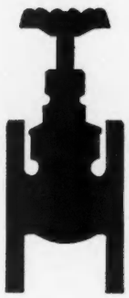

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(Left) To B.S. 1952. With flanged ends.

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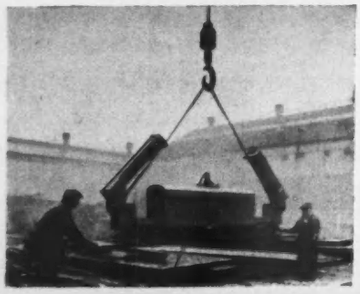

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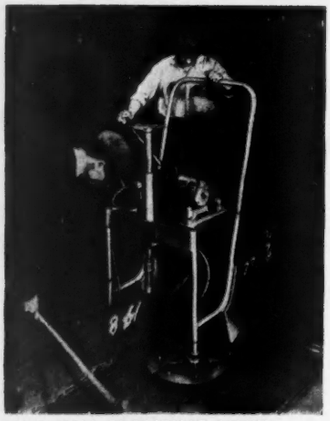

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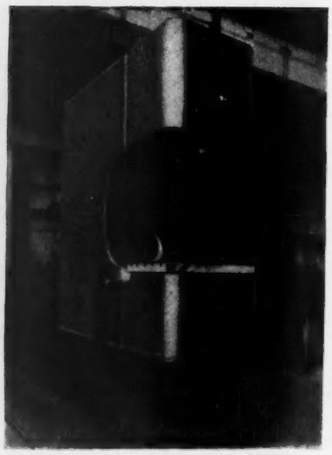

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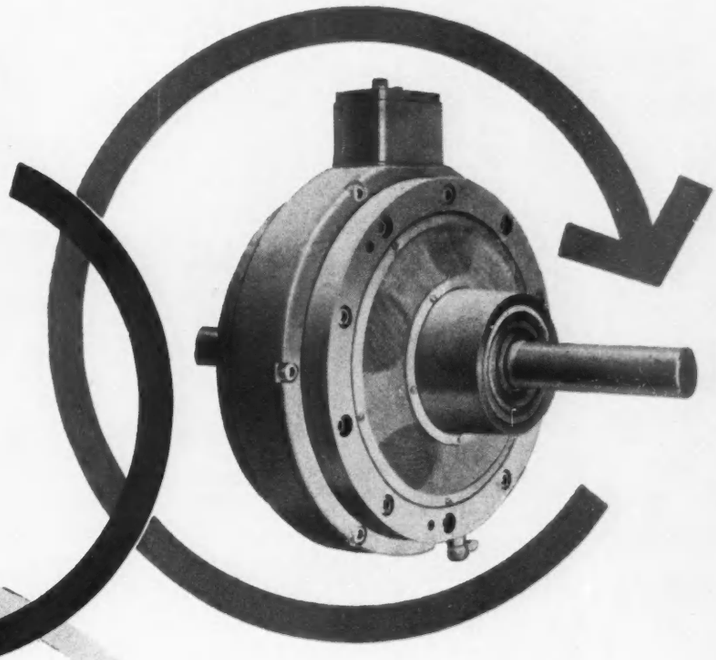

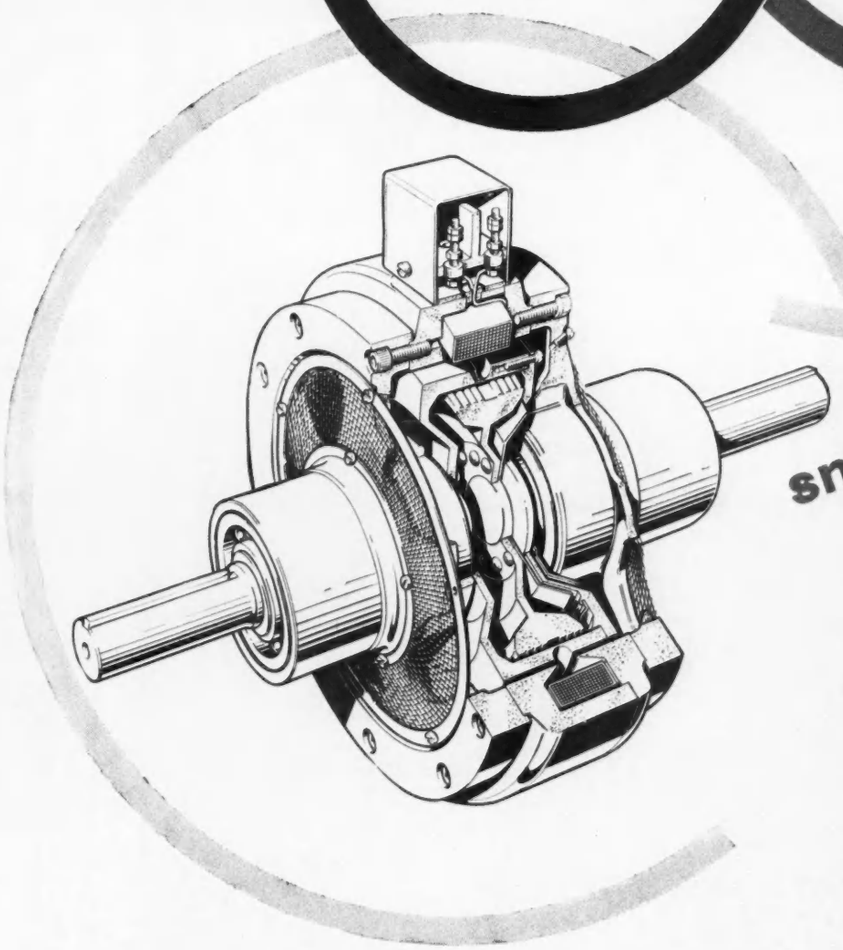

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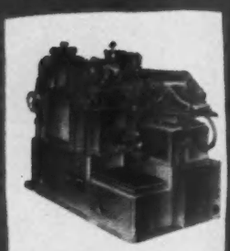

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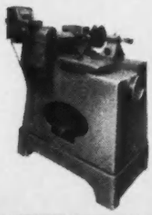

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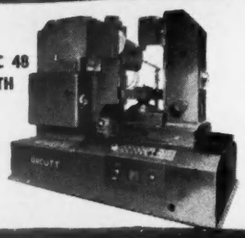

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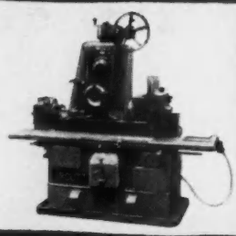

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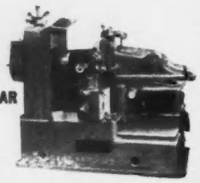

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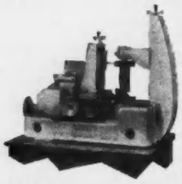

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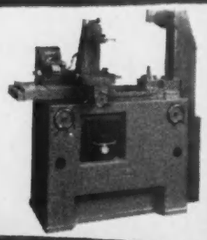

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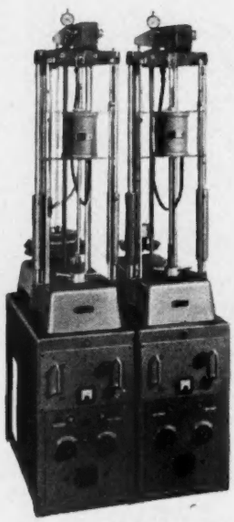

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MODEL T.45A Capacities
5 tons and 15 tons

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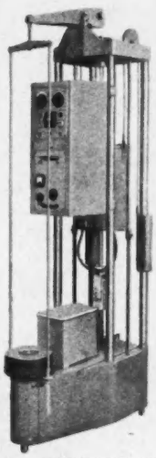

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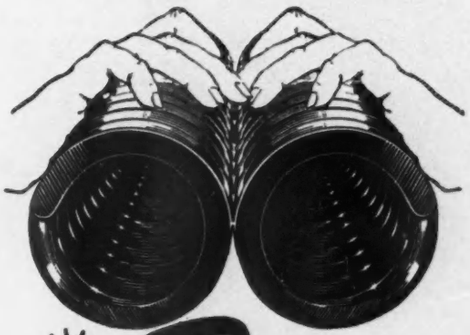

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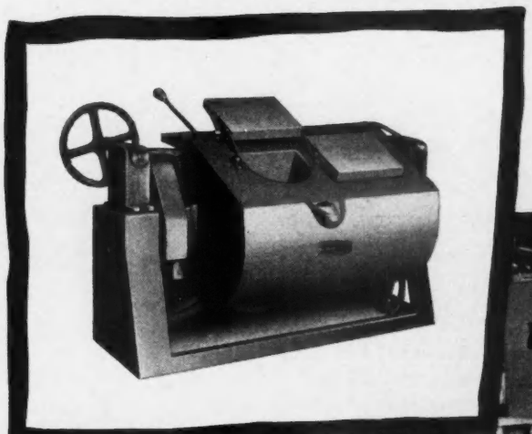

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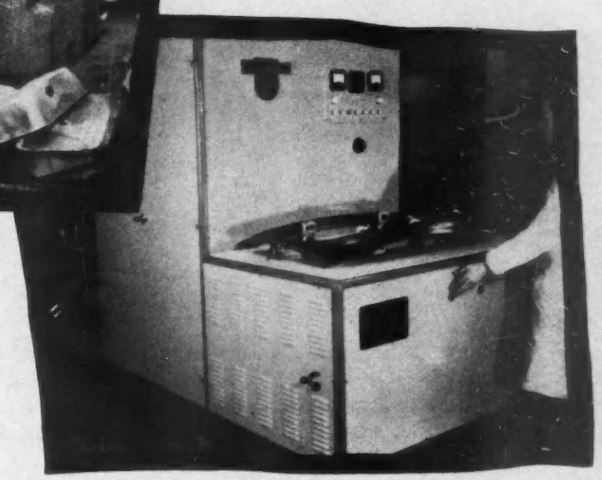

Right: Stress-relieving body panels.

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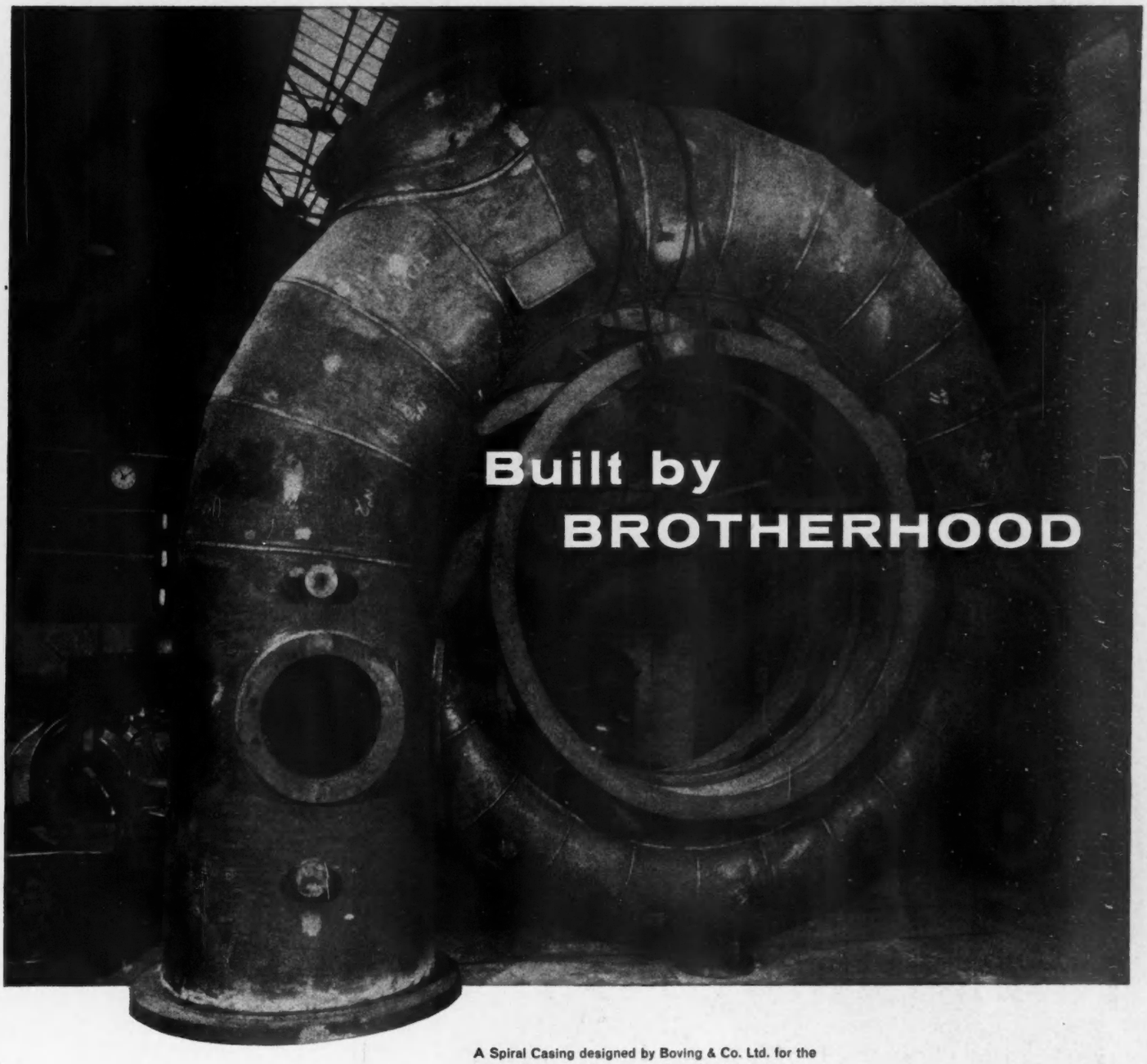

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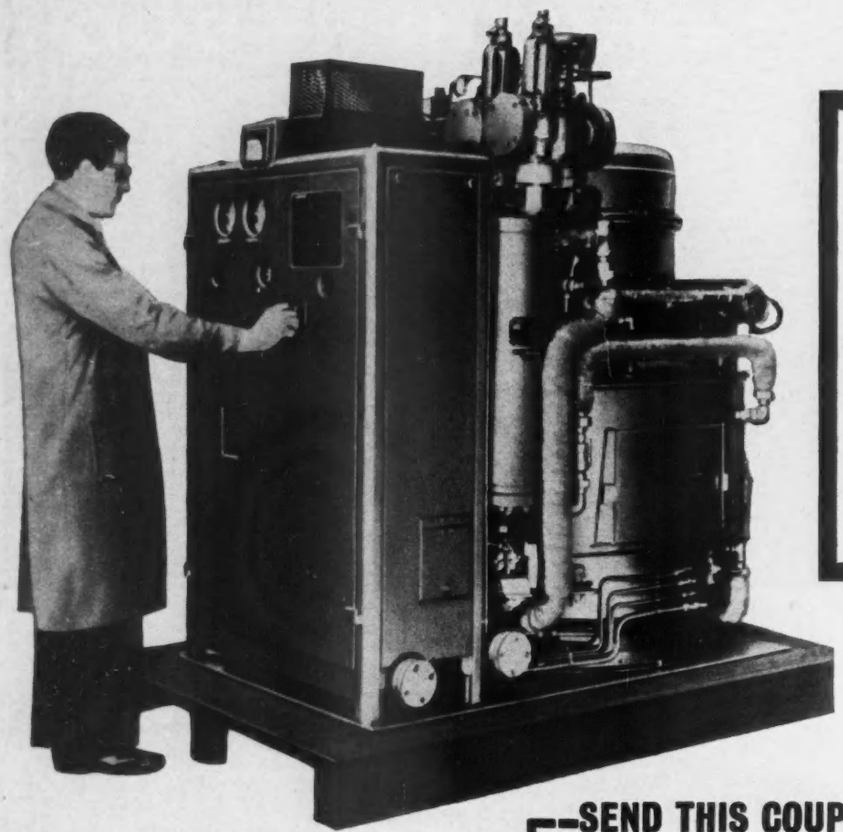
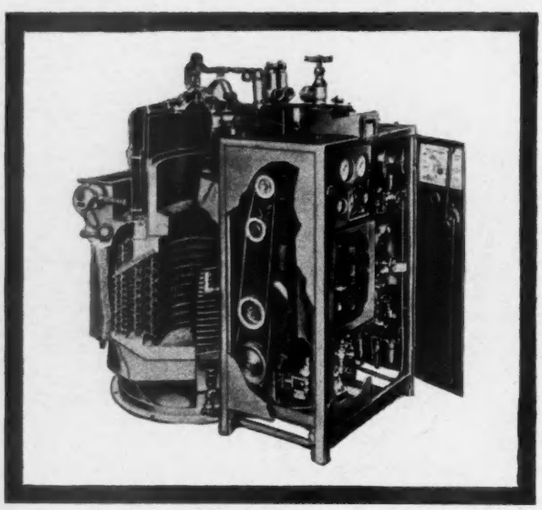


The fire-pot and air-ring of the Stone-Vapor steam generator are both of Inconel heat-resisting alloy.



Cut-away view of 'package boiler' produced by J. Stone & Co. (Deptford) Ltd. It is ideal for use in ships, trains, factories, laundries, and wherever high-quality steam is required economically.

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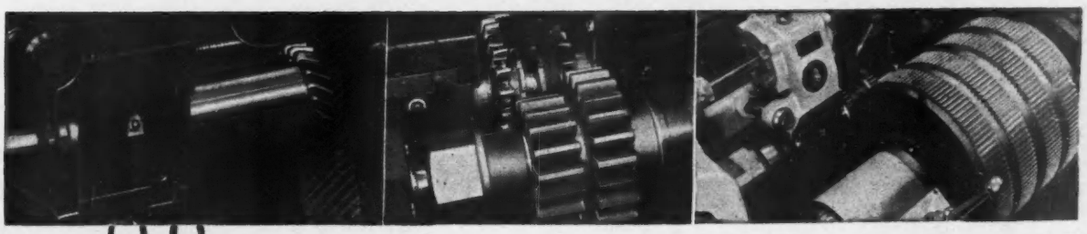

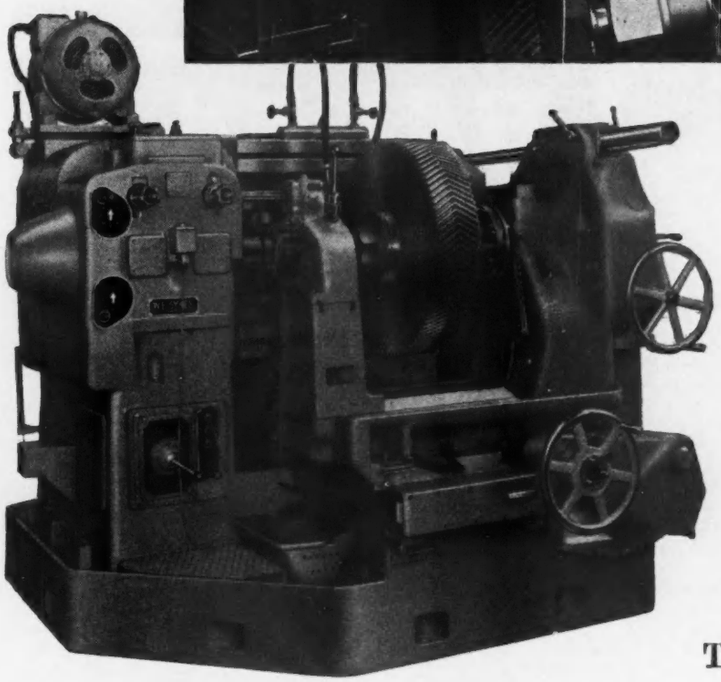

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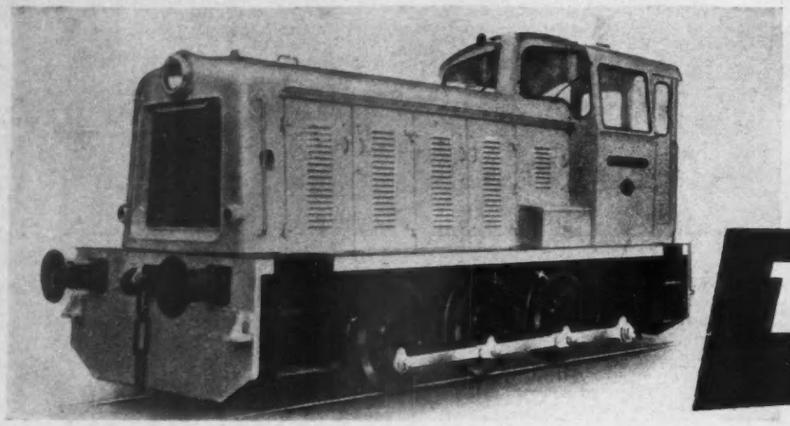

Diesel Mechanical
Wheel arrangement 0-6-0
Dorman 6QA diesel engine 232 H.P. at 1700 r.p.m.
Weight 29 tons
Starting Tractive Effort 19,500 lbs.

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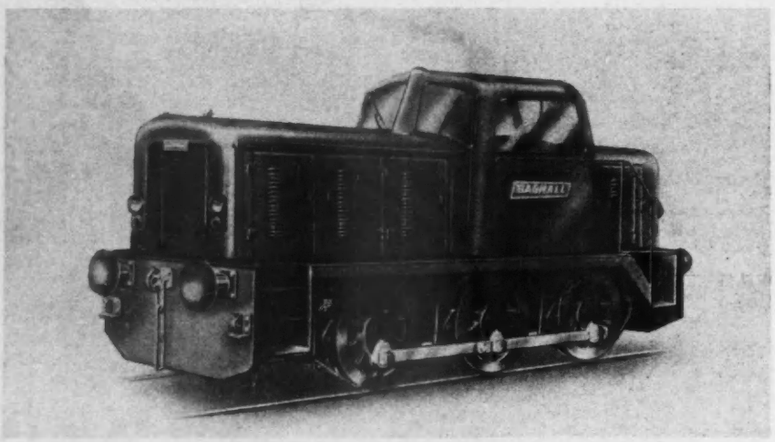

Diesel Hydraulic
Wheel arrangement 0-6-0
Dorman 6QAT diesel engine 342 H.P. at 1800 r.p.m.
Weight 48 tons
Starting Tractive Effort 32,300 lbs.

Bagnall are always on the rails right from the design stage — when it comes to locomotives: mostly diesel. They plan them, design them, build them, and power them with any first class diesel engine — Dorman, for example. And they're the best, here and throughout the world.

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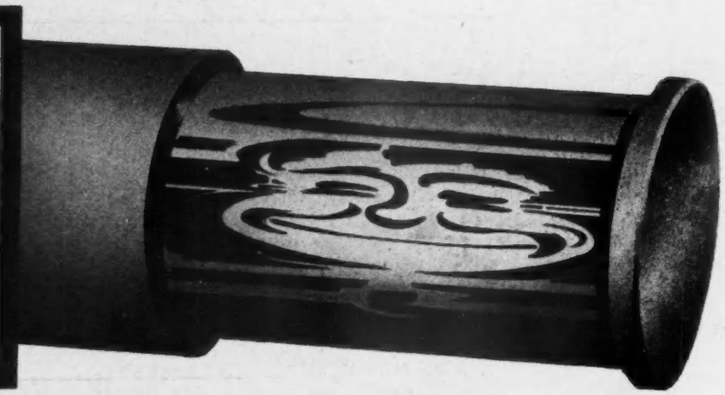

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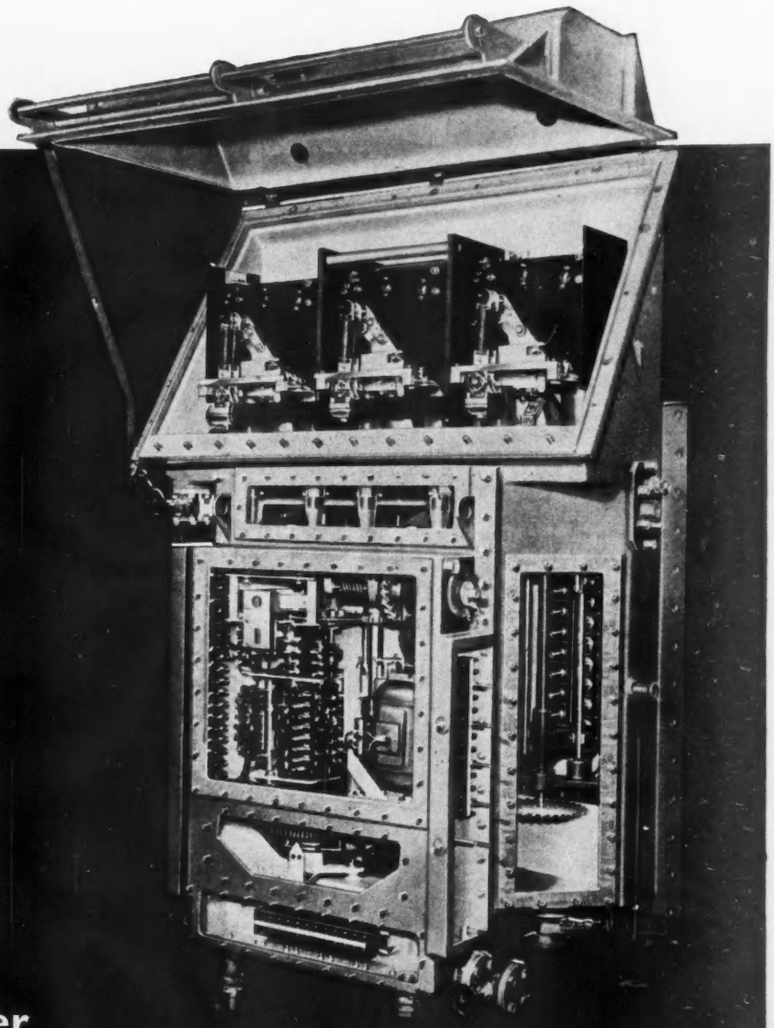
D.C.3.



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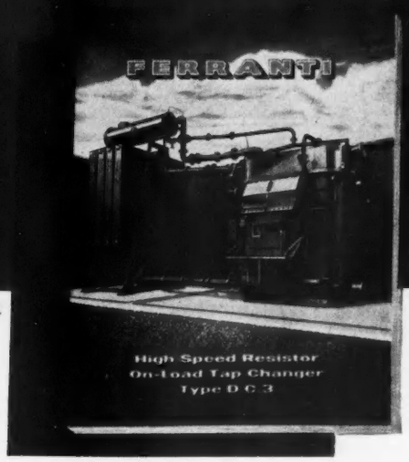
Type D.C.3



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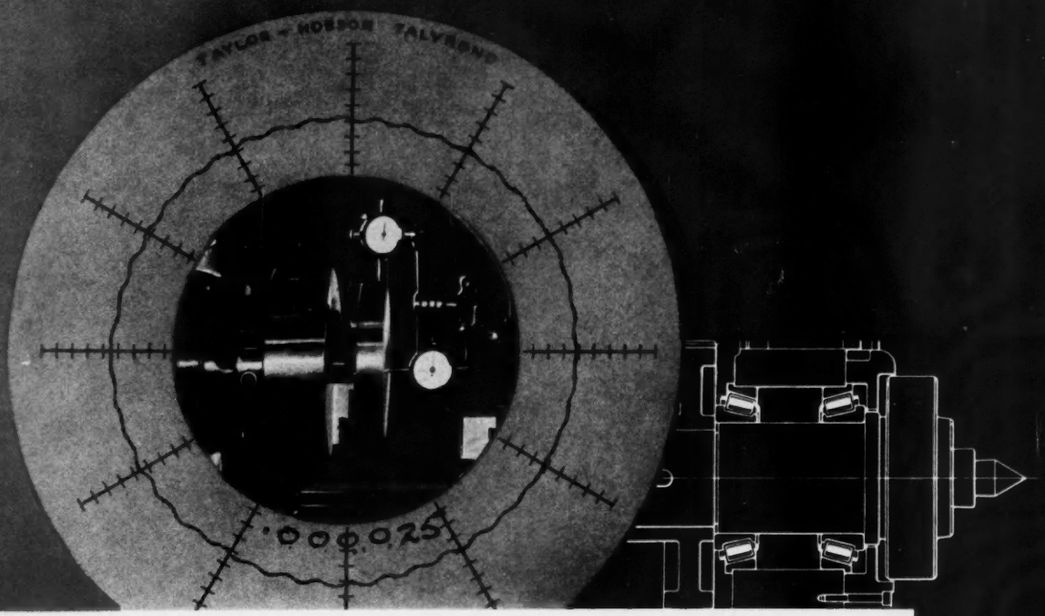

High-precision bearings

Timken high-precision bearings are made expressly for machine tools and other applications needing great accuracy. The above photograph shows two of the tests on a Model 'D' NO. 18 HOLBROOK LATHE; the graph shows an enlarged Talyrond record, indicating the maximum out-of-round as ·000025", the limit for this lathe being ·0001". The 'camming' on the face was also ·000025"; other tests show comparable accuracy. These results are representative, the lathe being typical of the standard production. Full particulars of the three grades of Timken precision bearings, on request. British Timken, Duston, Northampton, Division of The Timken Roller Bearing Company. Timken bearings manufactured in England, Australia, Brazil, Canada, France and U.S.A.

Photograph by courtesy of Holbrook Machine Tool Co. Ltd., Harlow, Essex. Graph taken on Taylor-Hobson Talyrond. Sectional drawing shows the flanged Timken bearings on the front end of the work spindle: these bearings control the axial location in both directions.

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